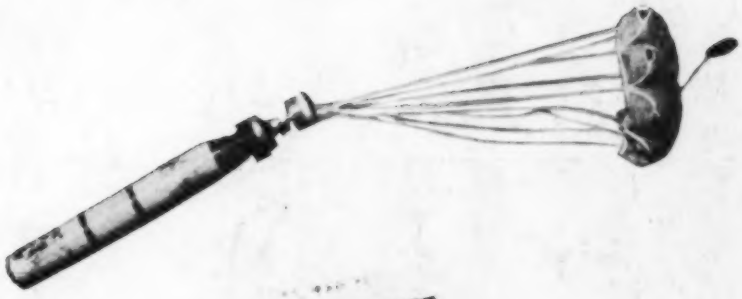
Vol. 1 No. 2 Second Issue



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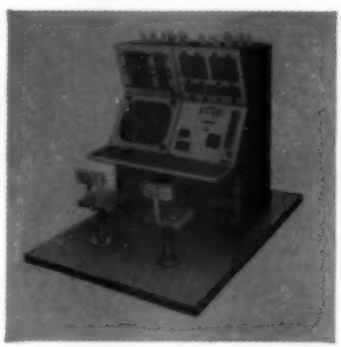

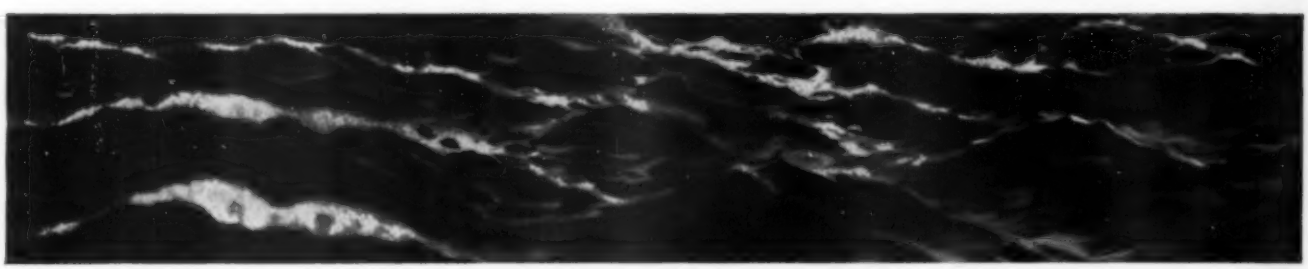

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One facet of U.S. Navy's anti-submarine warfare tactics, as shown by dropping of torpedo from Navy attack plane in ASW exercises. See various feature articles on torpedoes beginning on page 40. **Cover design by Joe Robbins, Washington, D.C.**

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# nautical notes

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**By Peer Fossen**

**Navy has discovered the LARC,** the U.S. Army Transportation Corps' new amphibious lighter manufactured by the Ingersoll-Kalamazoo Division of Borg-Warner Corp. Two versions are currently available, the smaller one capable of carrying 5 tons of cargo, and the latest version which can handle a 15-ton load.

* * *

**The LARC-5 has already undergone evaluation tests** at Navy's Little Creek, Va. facilities. The 15-ton amphibian is expected at Little Creek for testing later this Fall. Navy is primarily interested in investigating LARC's suitability to transport personnel and cargo from attack transport ships, such as LSTs, LSDs, and the new LPD. No particular problem is imposed in marrying ships of this type with the LARC.

* * *

**On larger ships, however,** where the amphibians would have to be brought on board by means of davits, certain modifications would be required. For instance, localized strength would have to be worked into the hull of the LARC to accept the concentrated load imposed by the davits. In its present form, the forward lifting eye would be positioned in the driver's seat. This situation can be rectified by taking one foot off the bow and adding it to the stern. Each davit would be able to handle three LARCS by nesting two on deck and leaving one in the davit.

* * *

**The LARC has also seen active duty on the space front recently.** According to reports to UE, NASA has borrowed two LARC-5 vehicles to retrieve test capsules fired under the Mercury program. In addition, the British will soon have one LARC for evaluation, the Australian Lighthouse Service has expressed interest, and the Navy of the West German Federation is keen on the idea of taking a closer look. So is Norway.

* * *

**The third generation of POLARIS submarines** will bear an illustrious name. The lead ship of the new class will be named *Lafayette,* in honor of the French marquis who became a hero in the American Revolution.

The *Lafayette,* designated SSBN 616, will be built by the Electric Boat Div. of the General Dynamics Corp. at Groton, Conn. Displacing about 7,000 tons, the *Lafayette* class submarines will be 425 ft long.

The first series of POLARIS submarines, with the *George Washington* (SSBN 598) as lead ship, displace about 5,400 tons each and are 380 ft long. A second family of these subs, the *Ethan Allen* (SSBN 608) class, have an overall length of 410 ft and displace 6,900 tons.

* * *

**Construction of five POLARIS submarines** was authorized by Congress for fiscal year 1961. The 618, to be built by the Newport News Shipbuilding and Drydock Co., will be the last of the *Ethan Allen* class submarines. The remaining three, the 617 to be built by Electric Boat and 619 and 620 to be built at Mare Island and Portsmouth (N.H.) shipyards, respectively — will be of the *Lafayette* class.

Announcement of construction plans for the 616 through 620 brings the Navy's POLARIS submarine count to two subs in commission (*George Washington* and *Patrick Henry*), seven under construction and five authorized for construction beginning this year, a total of 14 built, building or fully funded.

* * *

**It will be late this year before the Mare Island Naval Shipyard** begins work on the new POLARIS firing nuclear powered submarine assigned to it under the fiscal 1961 shipbuilding program. Reason: The long time required to get steel shipped from Eastern steel mills to the West coast.

**The attack submarine** *Scamp* becomes the Navy's 21st nuclear powered submarine when she slides down the ways October 8 at the Mare Island Naval Shipyard. She is the fourth atomic sub to be built at Mare Island.



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# editorial ★★★★★★★★★★★★★★★★★★★★★★★★★★

Every Russian trawler and every Russian oceanographic research ship snooping around, up and down our Pacific and Atlantic coasts, is a spy ship.

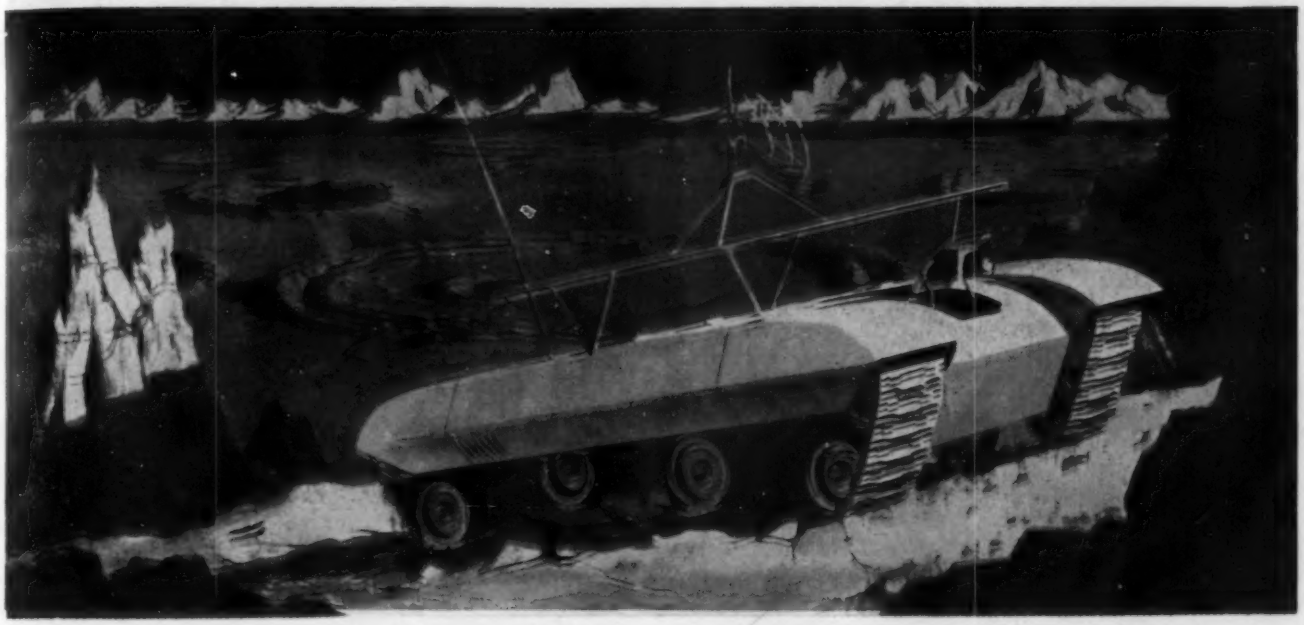
Every Russian scientist and every Russian skipper and crew member on any of these ships is working directly or indirectly for the Red military machine — as a spy. Now, what are the Russian trawlers and oceanographic research ships doing? What are they trying to accomplish by cruising in the waters off our coasts?

For several years, many people have been under the impression that the aim of Russian trawler spying was to obtain information on trajectories, velocity and other technological data pertaining to the launching of our various missiles from Cape Canaveral, or even the firing of POLARIS from submerged submarines.

It is not likely that the Russians have been paying much attention to Cape Canaveral. It is not likely that they are seeking information about our missile firings, because the Russians are still ahead of us in the area of guided missiles and space vehicles.

The crux of the matter is this: the Russian trawlers and oceanographic research vessels operating off our coasts are collecting a vast amount of immensely important military-scientific information of vital interest to a nation that might eventually attack the United States with her fleet of approximately five hundred long-range submarines. Russia could stage a blitz against the United States' mainland with a combination of her long-range missiles and aircraft and her rocket firing U-boats. In order to advance her submarine fleet in great numbers right into the strategic points off both North American coasts, Russian submarine skippers must have complete command over several oceanographic tasks: bottom topography; acoustics; transmission losses; and currents.

*These oceanographic areas are the ones* that are being studied and investigated thoroughly by the Russians. Information and results are being fed to the Kremlin — probably at a very rapid rate. And the calibrated interpretation of all this information will enable the Russian submarine fleet — someday — to stage a mass attack. At that time, the



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Russia's interest in oceanography is genuine. It began a long time ago, and it was activated at the beginning of the International Geophysical Year. They have a serious, scientific interest in oceanography, and if you take time out to analyze their IGY reports on oceanographic studies, you will notice that there is a definite trend toward high-level science in all the work that they have performed. In a way, you may conclude that half of their oceanographic research is scientific and of interest only to experimenters and researchers in the pure sciences. However, the other half lies in the grasp of the Kremlin itself and is a part of the vast Kremlin military intelligence system.

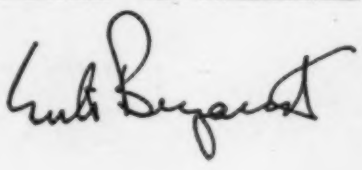
Top U.S. Navy experts are convinced the Russians are not ahead of us in oceanography. The Russians do not have better oceanographic research equipment. They do not have better oceanographic researchers or scientists. But the Russians have many, many more "research" ships, and many, many more "scientists" for this work than we could possibly hope to have within the next decade. Why? Because the Russians have staged a mass attack on the oceanographic research problem, have made it a national and a military project, and have trained more scientific personnel for this job than the United States.

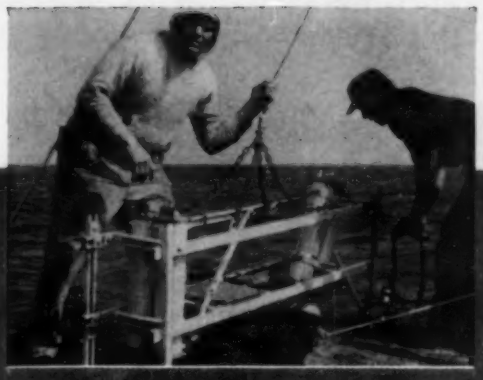
What can we do about it? Not much right now. Congress could grant all the money in the world tomorrow for a stepped-up U.S. oceanography program, but it wouldn't do any good, because we do not have the scientists available. It will take us years to train them. Furthermore, there is nothing we can do about the Russian trawlers and the intensive Russian oceanographic spying off our coasts. The Russians are clever enough to operate in international waters. Nevertheless, there is — perhaps — *something* we can do, right now; we can start to build up in our science-minded youth a greater interest for inner space, for the greatness of oceanography. We can make oceanography popular, we can offer better salaries, we can begin to open the public's eyes to the fact that a Russian attack on the United States will come from *under* the oceans as well as *over* the oceans.

Meanwhile, the Russians will continue to map the bottoms of the seas — up and down both coasts of North America — and perhaps prepare themselves for that big blow that we all pray will be avoided . . .

Now, here is an amplifying piece of news from the Soviet: the Reds are preparing a fleet of two hundred electronically armed trawlers for oceanographic work. Modern equipment includes depth finders and plotters, sonar, radar, temperature, pressure and current probes.

And their submarine ship building program is advancing at full speed.





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# capital report

**By Alfred J. Zaehringer**

**USSR is preparing a fleet of 200 electronically armed trawlers** for oceanographic work. Modern equipment includes depth finders and plotters, sonar, radar, temperature, pressure, and current probes.

* * *

**Quietest sub in the fleet is said to be the newly launched SSK (N)-597,** *Tullibee*. Built by Electric Boat Div., the 273-ft long hunter-killer sub is the first to be equipped with a turbo-electric drive. The sub also employs special gear to eliminate any possible sonar noises.

* * *

**Revitalization of submarine air will probably limit all-underwater operation** to around 120 days, according to a report of Electric Boat. Although improvements in systems are expected, dramatic breakthroughs will probably not come in the near future.

* * *

**Weight and size parameters of underwater vessels** have been analyzed by U.S. Naval Ordnance Test Station at Pasadena, Calif. These have been reduced to a series of equations directly giving total volume and weight of a UW system for a given speed and range.

* * *

**Blast-off is a possible new nautical term** for rapidly cutting a ship's mooring lines. A circular shaped charge fits around steel cables up to 1⅛ to 2⅛ in. in diameter and cuts them in ten one millionths of a second. The device is being developed by the Hunter-Bristol Div. of Thiokol. Another shaped charge cutter is being developed by Underwater Explosives Research Div., Norfolk Naval Shipyards, Portsmouth, Va.

* * *

**Magnetic Field Facility has been constructed** at U.S. Naval Engineering Experimental Station, Annapolis, Md. Advances in naval undersea warfare have given increased emphasis to measurement and reduction of even low level magnetic fields which are produced by naval craft. Principal mission of the facility is to research magnetic countermeasure devices and low magnetic field shipboard equipment, and also to provide a means of rapidly testing and analyzing prototype equipment under actual running conditions prior to installation.

* * *

**New installation at David Taylor Model Basin near Washington, D.C., includes:** maneuvering and seakeeping facility (MASK) for surface ships and subs, which includes two test tanks, a 36-in. variable pressure water tunnel to evaluate propulsion, cavitation, and noise characteristics of ship props; and a 1,500 psi structural test tank used to simulate depth of water above a sub in order to check hull strengths of structural models.

* * *

**PCH is the designation for Navy's sub chaser, hydrofoil.** This craft, which is to have a speed greater than conventional ASW ships, will be 115 ft long, displace 110 tons, and will have a 32-ft beam. It will have a long flying range and an even longer cruising range, will be equipped with the latest sonar, and heavily armed with anti-submarine weapons.

* * *

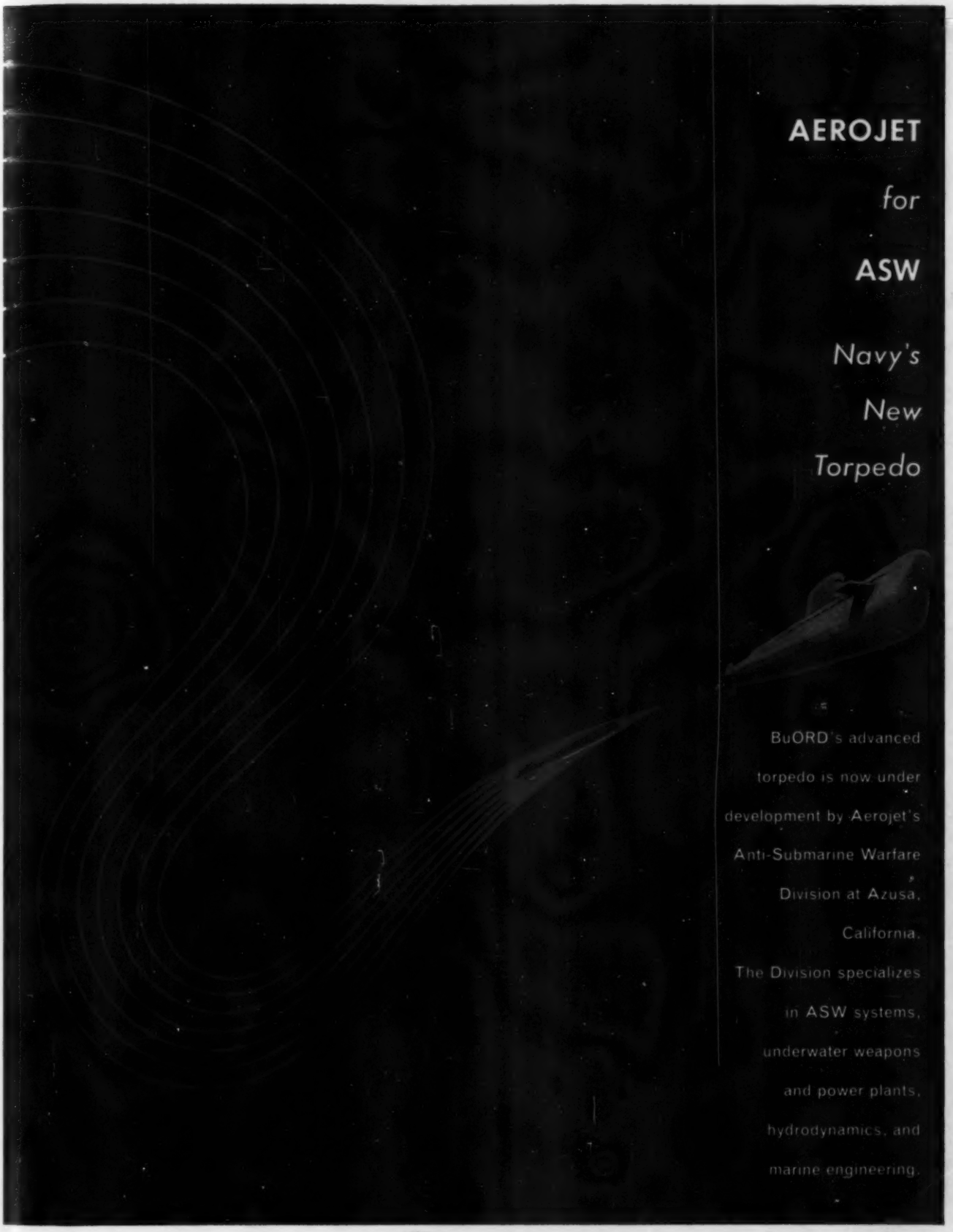
**Cargo-carrying or combat subs have been investigated** at Garfield Water Tunnel, Ordnance Research Lab., Penn State U. Machinery weight is an important parameter of the hydrodynamics of submerged bodies. Underwater analogs of the ducted fan, ramjet, and the rocket are regarded as being the most important for future vessels. The drag-to-weight ratio allows large bodies to travel at greater speeds than smaller bodies. Use of boundary layer control and rocket propulsion is predicted.

* * *

**Propellants for torpedoes,** according to Experiment, Inc., might involve use of free sea water as diluted oxidant with aluminum or zirconium fuels. In such a system, the performance of aluminum-sea water would be 114 hp-hr/cu ft (or 0.70 hp-hr/pound) while the zirconium analog would be 106 and 0.27, respectively.

* * *

**Underwater jet engine systems** include the hydroduct (ramjet), hydropulse (pulsejet), hydroturbojet (turbojet) and both solid and liquid propellant rockets. Aerojet-General concludes that rocket systems offer the greatest speeds (at reduced ranges) than those systems using rotating machinery.



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# underwater sidelights

By E. E. Halmos, Jr.

★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★

**A decision could come at any time on a proposal to use some of the Navy's huge World War II floating drydocks as missile launching pads.** The docks—some of them big enough to take cruisers (when put together in sections)—are actually floating barges that were towed halfway across the world during the Pacific campaigns and were one of the secrets of quick U.S. naval recovery after battles. Converting dock section to launching platforms would be relatively simple: "Legs"—huge pipe-piles—would be stuck through the surface and dropped to the bottom (just as in "Texas Tower" oil rigs, now in use) for permanent mooring to the ocean floor.

* * *

**Speaking of "Texas Towers," Coast Guard is beginning its long-standing program to eliminate 22 of the 24 stations** (mostly along the East Coast) now served by self-propelled lightships. Replacements will be towers of the "Texas" type, which can be floated to station, then permanently founded on the ocean bottom. CG has $1.5 million in its FY 1961 budget for two such stations—one off Buzzard's Bay near Boston, the other off Narragansett Bay in Rhode Island. The Buzzard Bay's tower will cost about $1 million and provide quarters for a "crew" of five men; the Rhode Island tower will cost $500,000, and will be an unmanned station.

* * *

**The Navy's Civil Engineer Corps was dragged—somewhat unwillingly—** into that recent series of blowups in the Pentagon over the alleged delays in construction of missile bases for the Air Force. It can be revealed that a fire-eating memo from AF's Gen. Curtis LeMay, criticizing the Army's Corps of Engineers, suggested getting Navy's Bureau of Yards and Docks into the construction picture, on the basis of its good record in building missile facilities at Naval installations. Upshot of the series of meetings held in the Pentagon was the reorganization of the Army's missile construction work under Brig. Gen. A. C. Welling — and a decision to let other construction matters stand until Welling had a chance to show what he can do. BuDocks stayed out of the argument, except to comment quietly that it would help if called upon.

* * *

**The discussion points up a basic difference in the way BuDocks and the Corps of Engineers** must operate: Corps is working with a separate service, the Air Force, which has jurisdiction over design of the missile and its appurtenances, and then turns this over to the Corps for translation into concrete and steel. BuDocks works with one of the Navy's own arms—the Bureau of Weapons—so it can work much more closely (it's said) with developments from start to finish.

* * *

**Navy's work on shore-based missile installations is considerable,** although there's been little publicity on it. Construction alone at Pacific Missile Range (Pt. Mugu, Pt. Arguello, San Nicolas Island, and various offshore bases) has called for expenditure of $10 million or more each year over the past several years. That takes no account of money spent on the Atlantic Missile Range, China Lake, and other support activities.

* * *

**Some idea of what the Navy is spending on underwater engineering** can be drawn from just a few of the items contained in the $1.1 billion military construction bill passed by Congress. The Underwater Sound Laboratory at New London got $4.4 million for construction of development and test facilities; the Naval Missile Center got $338,000; the Fleet Sonar School at Key West was assigned $1.1 million for construction of training facilities; and $1.9 million was set up for the Naval observatory at Flagstaff, Ariz., for development and testing facilities.

**Nuclear power plants for remote areas,** where fuel and supply are difficult or impossible, continue to be a major Navy interest. Right now, for instance, four sites (three of them in Antarctica) are under active consideration: Byrd and Pole stations and McMurdo Sound, and Guam. Barge or pier-mounted nuclear plants are considered to be feasible—these would be adaptations of presently-available nuclear plants, not entirely new concepts. Demonstration of the need is this: At McMurdo Sound, all electrical load is supplied by two 250 kw diesel generators, which are hard to supply and are not satisfactory. By 1962, the demand for power will approach 3,000 kw. At Byrd and Pole stations, 60 kw diesel generators supply all power.

* * *

**At the moment, there are five reactor plant types that could meet most of these power needs**—SM-1, SM-1A, PM-1, PM-2A, PL-2. However, none of these is pre-packaged, and all would have to be erected on the site—an extremely difficult and expensive operation. Navy would rather wait, if possible, for packaged plants.

* * *

**If you're wondering about those letters signifying Nuclear Power plant types** just above, here's the Navy's code, for future reference: First letter indicates plant mobility — S means stationary, P portable, M mobile; second letter indicates power range — L low power, M medium power, H high power; numeral indicates order of initiation of projects with same two-letter designation; capital letter following numeral indicates order of initiation of field plants of the same type.

* * *

**One of the great "firsts" in all history was little noted** except as a curiosity in the general press. It was the establishment of a commercial underwater storage system for fuels off the Florida Coast near St. Petersburg. Basically the concept of Dr. Harold G. Quase, a Washington, D.C., physician, the system consists simply of two-ply rubberized fabric bags, enclosed in wire mesh, which can be towed to location and moored in relatively deep water to store liquids and gaseous materials. The $250,000 St. Petersburg installation will be used to store drinking water, fuel, medicines and food, in the event of attack or hurricane. Such installations could also serve as permanent—virtually indestructible—hidden fueling stations for ships.

* * *

**Just to show the ramifications of engineering connected with the sea,** the British government is reported to be converting two small World War II aircraft carriers (13,000 tons) into fishery factory ships. Helicopters will transfer fish catches from trawlers to the factory ships, each of which will make four 90-day round trips to the fishing fleets each year. On board the big factories, the fish will be quick frozen for delivery to dealers ashore. Each of the carriers would require about 50 fishing trawlers to keep it supplied with fish.

* * *

**The immense waves generated in the Pacific after the recent earthquakes** in Chile have stirred a demand in Congress for improvements in the seismic sea wave warning system. Such waves can travel at a speed of 450 miles per hour. At the moment, the existing warning system includes five Geological Survey seismological stations, each equipped with visible recorders and an alarm alert. They are located at Fairbanks and Sitka, Alaska; Tucson, Ariz.; Guam and Honolulu, with the Honolulu station acting as nerve center. Peruvian, Japanese, Philippine and other foreign governments also cooperate, as does the U.S. Navy, Cal Tech, and others. Problem is that no means has been worked out of making reliable predictions as to the actual damage the waves may do after detection. Geological Survey wants more money for a study program. Understandably, Hawaii's two Senators are strongly backing the proposals.

* * *

**The U.S. has agreed to give active support to an international expedition** to the Indian Ocean that will last nearly four years. The expedition will be under the leadership of a special committee of the International Council of Scientific Unions, headquartered at The Hague, Holland. The National Academy of Sciences will carry the scientific participation load for the U.S. Peak activity in the Indian Ocean will occur in 1962 and 1963, when ships and personnel from more than a dozen nations will conduct basic research in physical and chemical oceanography, meteorology, marine biology, geophysics and submarine geology. Although the Indian Ocean covers 14 per cent of the earth's surface, very little is known of it. Nowhere else in the world is there a similar seasonal reversal of the prevailing wind. Its productivity of fish is known to be phenomenal.

# undercurrents

*By William L. Sturdevant, Jr.*

Industry is beginning to see the economic potential of oceanic research. One result is a flow of money into deep-sea activities formerly financed almost exclusively by institutions and government.

Example: Reynolds Metals has developed a deep-diving, all-aluminum submersible called the Aluminaut. Experts believe it has real potential as a naval research ship and perhaps as the forerunner of a radically new kind of submarine. Reynolds is financing construction of the vessel by Electric Boat Div., Groton, Conn., and will turn it over to Woods Hole Oceanographic Institution for probable lease to the Office of Naval Research.

Example: Two officials of Texas Instruments, Inc., Dallas, have given $7.5 million to Massachusetts Institute of Technology for development of earth sciences, including oceanography. M.I.T.'s expanded oceanography program includes an interchange of students and scientists between M.I.T. and Woods Hole. The Texas money has no strings attached to it, and the company exercises no control over how it is spent, but M.I.T. obviously will not overlook the potential commercial aspects of its research.

Reynolds' financing of the Aluminaut construction does not mean the craft lacks favor within the Navy. The Office of Naval Research included Aluminaut funds in its budget but the item was vetoed by the Bureau of the Budget.

Most of the gift to M.I.T. came from Cecil Green. He gave $6 million—$5 million for a new earth sciences building and $1 million for its maintenance. The other official, Eugene McDermott, gave $1.5 million for scholarships—preferably for students from Texas or other states in the Southwest, and preferably for study in earth sciences. (This field covers not only oceanography but geology, geophysics, meteorology, and geochemistry.)

Oceanographic experts on Capitol Hill are gratified by industry's early response to the needs of ocean science. Up till now industrial interests in the sea lay mostly in engineering ventures such as oil drilling and cable-laying, and contract research in the field of military oceanography.

Obviously, the Federal Government will continue to play the lead role in a national oceanographic program. Oceanography has not yet shown enough promise of direct commercial pay-off to attract great amounts of private risk capital. But, as the House Committee on Science and Astronautics said in a recent report:

"Studies of substance are almost completely lacking regarding either the promise for commercial exploitation of the sea or the mechanism by which this could be fostered. Such a study would go far to reveal profit potential as well as means by which the Government, through incentive programs and seed capital, could interest industry in undertaking more research on its own."

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# LETTERS TO THE EDITOR

*To The Editor:*

Congratulations on Underwater Engineering magazine.

Recognition that Russia's greatest limited-war threat is her huge submarine fleet can be fostered by this publication. A concerted force that presses for understanding of the needs in oceanographic and undersea warfare research can importantly aid our country's defense posture.

John F. Richard
Engineering Consultant
911 - 25th Street, N. W.
Washington, D. C.

*Thanks a lot. Ed.*

*To The Editor:*

After reviewing a copy of your publication, Underwater Engineering, I would appreciate being placed on your mailing list to receive subsequent copies.

This type of material has been long overdue in our field and will most certainly prove invaluable.

Varoujan Karentz
Field Project Manager
Airborne Equipment Center
Raytheon Co.,
Sudbury, Mass.

*Thank you. Your request is being forwarded to our circulation dept.—Ed.*

*To The Editor:*

It was a pleasure to see you the other day at the Press Club and may I compliment you on the splendid issue of Underwater Engineering which you so graciously gave me. I will route it around to my staff for their reading. All good wishes.

W. F. Raborn, RAdm., USN,
Director of Special Projects
U.S. Navy.

*Our very special thanks to "Red" Raborn — "Mr. POLARIS."—Ed.*

*To The Editor:*

I recently saw the first issue of your new publication, Underwater Engineering. It contained a good deal of excellent information. This magazine would be quite useful in my work, and I would like to apply for a subscription. If there is a copy of Volume 1, No. 1, available, I would appreciate receiving it. I thank you for any attention you give this matter.

Arthur P. Stoliar
Principal Engineer
Applied Science Dept.
Bulova Research & Development
Laboratories, Inc.
Woodside, N.Y.

*Thank you, and your request also has gone to the circulation dept.—Ed.*

*To The Editor:*

Thank you very much for your letter of 28 July 1960 which offered, as a service to the U.S. Navy, your new publication, Underwater Engineering, to the Submarine Force.

One hundred forty copies are required for complete distribution to this Force, allowing two copies for each submarine and one copy for Squadron and Division Commanders.

You are to be congratulated on your first issue of Underwater Engineering; it appears to be a fine magazine. Keep up the good work.

C. C. Heidel
Commander, U.S. Navy
Force Material Officer
Staff of Commander
Submarine Force
U.S. Pacific Fleet,
F.P.O., San Francisco, Calif.

*To The Editor:*

In your letter of 28 July 1960 you graciously offered to supply each U.S. submarine with two copies of your magazine, Underwater Engineering, and requested the number of copies necessary to effect such distribution.

We would be most pleased to distribute the magazine; however, one copy to each submarine staff would be a more effective distribution in getting the magazine in the hands of the people who will benefit by it. Ninety copies will allow us to do this for all submarines and staffs in the Atlantic Fleet.

Thank you for your interest in the Submarine Force.

J. H. Stevens, Jr.
Commander, U.S. Navy
Flag Secretary
Staff, Submarine Force
U.S. Atlantic Fleet

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# here's the asw market:

**UE Staff Report**

The underwater engineering market is an expanding market. Consider these facts:

- The minimum anti-submarine warfare (ASW) portion of the Navy's budget for Fiscal Year 1961 totals $1.42 billion. This excludes the costs of military personnel and operations and maintenance, and does not take into consideration that practically all ships and aircraft are concerned with ASW.
- There is a never-ending search for improvement in underwater engineering capabilities. The Navy is the first to recognize that its overall ASW capabilities are still far from satisfactory.
- There is not a single piece of the Navy's ASW equipment which cannot be improved. This is a challenge to American industry.

To contain the Soviet submarine force, whose capabilities are improving rapidly, the Navy needs:

1) Warning systems that will indicate the presence and locations of submarines in deep ocean areas, in convoy or task force areas, and in special areas not covered by the other systems.

2) Identification systems that will recognize enemy submarines and not give false alarms when schools of fish or whales approach.

3) A prediction system, similar to existing weather prediction systems, for forecasting sound propagation conditions over wide areas.

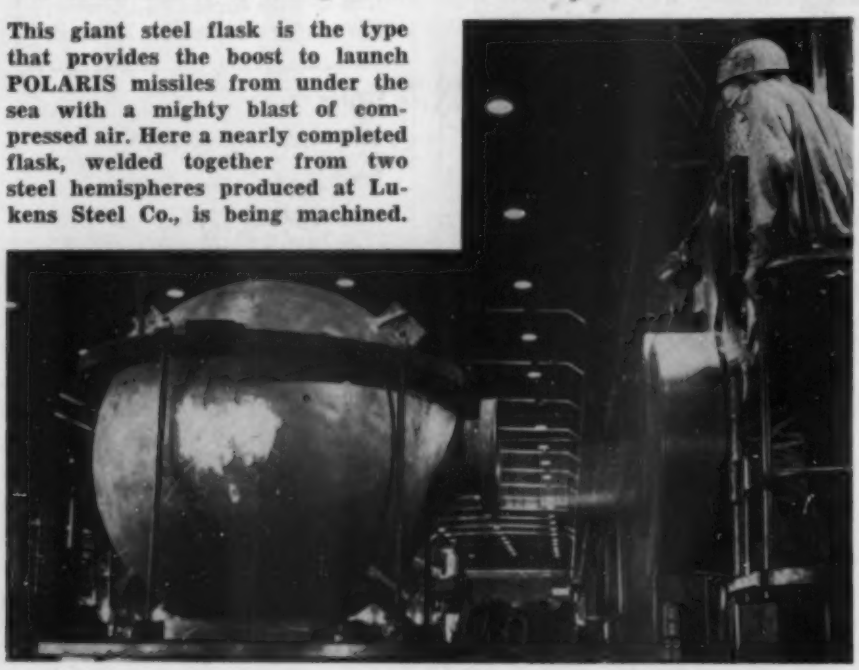
4) Certain detection of any submarine which exposes any part of itself above the surface.

5) Discovery and use of phenomena, other than sound, for location of submarines — even though sonar is still the most promising submarine detection field.

6) Weapons with range and accuracy equal to the detection ability of the Navy's equipment, so that a submarine found can be a submarine destroyed.

In order to aid and encourage industry's participation in the underwater engineering market, the Navy is streamlining its procedures for the reception and consideration of new ideas. Furthermore, it is increasing the release of classified information to those companies capable of helping it solve ASW problems.

The Navy's original budget plans called for $180.5 million for ASW



**This giant steel flask is the type that provides the boost to launch POLARIS missiles from under the sea with a mighty blast of compressed air. Here a nearly completed flask, welded together from two steel hemispheres produced at Lukens Steel Co., is being machined.**

research, development, test and evaluation during fiscal 1961. Congress, however, felt there was room for improvement in this field, and voted $50 million extra, bringing total ASW RDT&E money to $230.5 million.

The Navy had planned to spend its original ASW RDT&E budget as follows: $63.4 million for classification, detection and localization; $64.2 million for weapons, ordnance and fire control; $29.6 million for vehicles and propulsion equipment; $23.3 million for collateral, supporting and related equipment.

Defense has released $41.886 million of the added-on $50 million. This money is expected to be spread out fairly evenly among the various ASW research projects.

Congressional concern about our ASW status brought charges by the House Appropriations Committee that the Navy was lagging in its ASW development program. It charged that there was "no indication" that the Navy was giving "dramatic or dynamic leadership," and suggested that the Navy set up a single manager system for ASW work similar to that being used for the POLARIS system.

Admiral Arleigh Burke, Chief of Naval Operations, later appeared before the Senate Appropriations Committee and voiced strong protest against the House Committee suggestion.

Adm. Burke said the ASW program involves nearly all elements of naval operating forces and impinges heavily and directly on the procurement of ships, aircraft and associated weapons. "If any one person could be considered as a single manager of the anti-submarine warfare program that individual would have to be the Chief of Naval Operations," he said.

The CNO also explained that the Navy is well aware of the ASW problems, and in order to keep constantly abreast of developments he has established within his own office an Anti-submarine Warfare Readiness Executive charged with ASW planning and direction. Additionally, the Secretary of the Navy has formed an Anti-submarine Warfare Committee to provide top level policy direction.

Adm. Burke suggested that Capitol Hill leave the ASW program alone for awhile so that the program could be continued "without the disruption" of a major reorganization.

A major portion of the Navy's research effort is going into attempts to increase acoustic detection ranges. Of the more than 100 ASW research projects, about half are concerned with acoustics and oceanography.

In oceanography, coordinated research is being conducted by both naval and civilian laboratories. These programs support 16 oceanographic research ships. In 1961 the Navy plans to allocate $17.7 million to oceanography, compared with $14.5 million in 1960.

The Navy's Hydrographic Office notes that there is a great need for adequate oceanographic research and testing equipment. The cost of developing the average instrument prototype is about $75,000. For production engineering of the prototype, an additional $100,000 is normally required. The cost of thoroughly testing and evaluating the instrument in its various stages is about $5,000.

Important ASW research programs

**"Hydrokeel," prototype of a new concept in water-borne craft, in operational test by the Anti-Friction Hull Co. near Annapolis, Md. The craft is 24 ft long and eight ft wide. It weighs two tons and is powered by two Mercury 800s for propulsion, and one Harley-Davidson 45 cu. in. motorcycle engine for generating air lift. Blowers under the boat induce it to rise until only the knife edges of the longitudinal keel remain in the water. Craft is capable of speeds over 40 knots.**

are the various submarine surveillance investigations, including the Atlantis Project. This project, which seeks to overcome the different ocean surveillance problems in the Atlantic and Pacific, studies both air and sea detection systems. The Navy expended $10 million on Atlantis in fiscal 1960 and will spend $42.5 million in fiscal 1961.

In ASW hydrodynamic research (hydrofoil craft, submarine and destroyer hydrodynamics and exploratory ship design), the Navy will spend between $6.308 million and $10.038 million in fiscal 1961.

Strangely enough, mine warfare and mine defense measures, always an important part of ASW, have low priority in the Navy's program. In 1961 the Navy will spend about $12 million for mine warfare research. This is a reduction of about 15 per cent from the previous fiscal year. However, the mine research program does include some new types, such as a moored type capable of being put down by submarines and two by air, all of which are highly effective against submarines.

Important developments in ASW ordnance are the Mk-44 acoustic torpedo; the wire-guided Mk-37 torpedo for use by destroyers and submarines; ASTOR, a long-range, high-speed, wire-guided wakeless nuclear warhead torpedo for use by submarines against submarines and surface ships; and ASROC, a ship-launched rocket-assisted torpedo for use against submarines.

Some $55.2 million has been appropriated for procurement of ordnance and ammunition for the Navy's ASW forces in fiscal 1961. Emphasis in this procurement is on ASW torpedoes and ASROC.

The role of electronics in ASW is to detect, track and classify submarines. Funds for fiscal 1961 total $27.6 million, better than $880,000 over the ASW electronics procurement for fiscal 1960. Biggest portion of the electronics money — $22.015 million — is allocated for buying sonar and detection equipment.

An important part of the electronics procurement program is sonobuoys. To be certain that it gets more reliability in its sonobuoys, the Navy is tightening up specifications and requiring standardized production. Sonobuoy procurement will be spread out in six different contracts.

ASW communications — the use of high frequency direction finding equipment to locate submarines — is scheduled to cost the Navy $3.060 million in fiscal 1961. About $5 million has been programmed for procurement in each of the years 1962 and 1963. Installation of this special equipment will begin in fiscal 1962.

A substantial portion of the Navy's 1961 ASW budget — $345.2 million — goes for aircraft and related procurement. All combat aircraft in Navy squadrons have ASW functions, and carrier task forces constitute a major anti-submarine deterrent.

One of the new land-based ASW aircraft is the P3V-1, a special adaption of the Lockheed Electra commercial transport. The new carrier-based ASW aircraft, the S2F-3, will improve the capability of hunter-

## ASW Portion of Navy Budget

**(in millions)**

**Navy Appropriation**

| | Fiscal Year 1959 | Fiscal Year 1960 | Fiscal Year 1961 |
|---|---|---|---|
| Research, Development, Test and Evaluation | (1)$202.7 | (2)$225.3 | (3)$230.5 |
| Shipbuilding and Conversion | 1,012.6 | 485.7 | 762.3 |
| Aircraft and Related Procurement | 266.3 | 476.8 | 345.2 |
| Procurement of Ordnance and Ammunition | 54.1 | 50.2 | 55.2 |
| Major Electronics Procurement | 60.1 | 37.9 | 27.6 |
| **Total, all appropriations** | 1,595.8 | 1,275.9 | 1,420.8 |

(1) Includes $20,500,000 DOD Emergency Funds
(2) Includes $45,000,000 Congress Add-on
(3) Includes $50,000,000 Congress Add-on

killer groups when it replaces the old and overloaded S2F-1s now in use. Also a newcomer to the ASW team is the Sikorsky HSS-2, the Navy's first all-weather ASW helicopter.

With all the talk about fast-flying jets, the Navy looks for slow-flying propeller-driven aircraft in its ASW forces. It seeks to develop new aircraft equipped with the most modern submarine detection gear.

Blimps, long a favorite ASW weapon, apparently are on the way out. The Navy feels the blimps are too expensive to operate and too vulnerable to adverse weather conditions while on ASW patrols. The annual operation and maintenance cost for one lighter-than-air ZPG-2W is $325,133, compared with $193,273 for a P2V-7 aircraft employed in ASW work. As the blimps are being phased out, a few will be kept in service to maintain "the state of the art."

**Navy frogman tests new sonar equipment developed to locate underwater objects. The light-weight system is powered by standard flashlight batteries and was jointly designed by Stromberg-Carlson-San Diego and the Navy Electronics Lab.**

The biggest portion of the Navy's ASW money for fiscal 1961 — $762.3 million — is earmarked for ship construction. The ASW ships are:

1) Three guided missile frigates, to be built by private shipyards. In addition to operations with anti-sub forces, the DLGs will operate offensively in carrier striking forces and amphibious forces. Their guns, plus TERRIER and ASROC missiles, make them a particularly versatile offensive unit in anti-surface, anti-sub warfare and in support of amphibious operations. The cost is about $76 million each.

2) Two guided missile destroyers, costing $44.4 million each, to be built by private yards. These DDGs will be about a third larger than World War II destroyers and will have much better seakeeping qualities. They will serve with hunter-killer groups in the destruction of enemy submarines, in support of amphibious assault operations, and in screening convoys against submarine, air and surface attacks.

3) Two escort vessels, costing $25.25 million each, designed for optimum performance in locating and destroying enemy submarines. To be built by commercial shipyards, the DEs will carry the integral bow-mounted, long-range sonar, and Drone Anti-submarine Helicopters (DASH). They will also have ASROC launchers and anti-submarine torpedo launchers.

4) Four nuclear-powered attack submarines, costing $57.2 million each. These are two more than requested by the Navy, and with the three per cent cut in procurement funds, ordered by Congress, the Navy probably will not build three of these four. The SSNs are due for construction by private builders.

5) One oceanographic research ship, costing $4.9 million, to be assigned to a private shipyard. The floating laboratory, civilian manned, will conduct oceanographic research for application in naval warfare, particularly ASW.

6) One escort research ship with an experimental hull of advanced hydrodynamic and propulsion design. It will be used to obtain data for determining the optimum configuration for mounting sonar. The Navy will build only one ship of this type. It will cost about $29.3 million, and will be assigned to a private builder.

7) One deep diving auxiliary submarine, already assigned for building by the Portsmouth, N.H., Naval Shipyard. This AGSS will give the Navy a small vehicle for experi-

mental development of hull structure, sonar equipment, and weapon systems for combat subs. It will cost about $20.8 million.

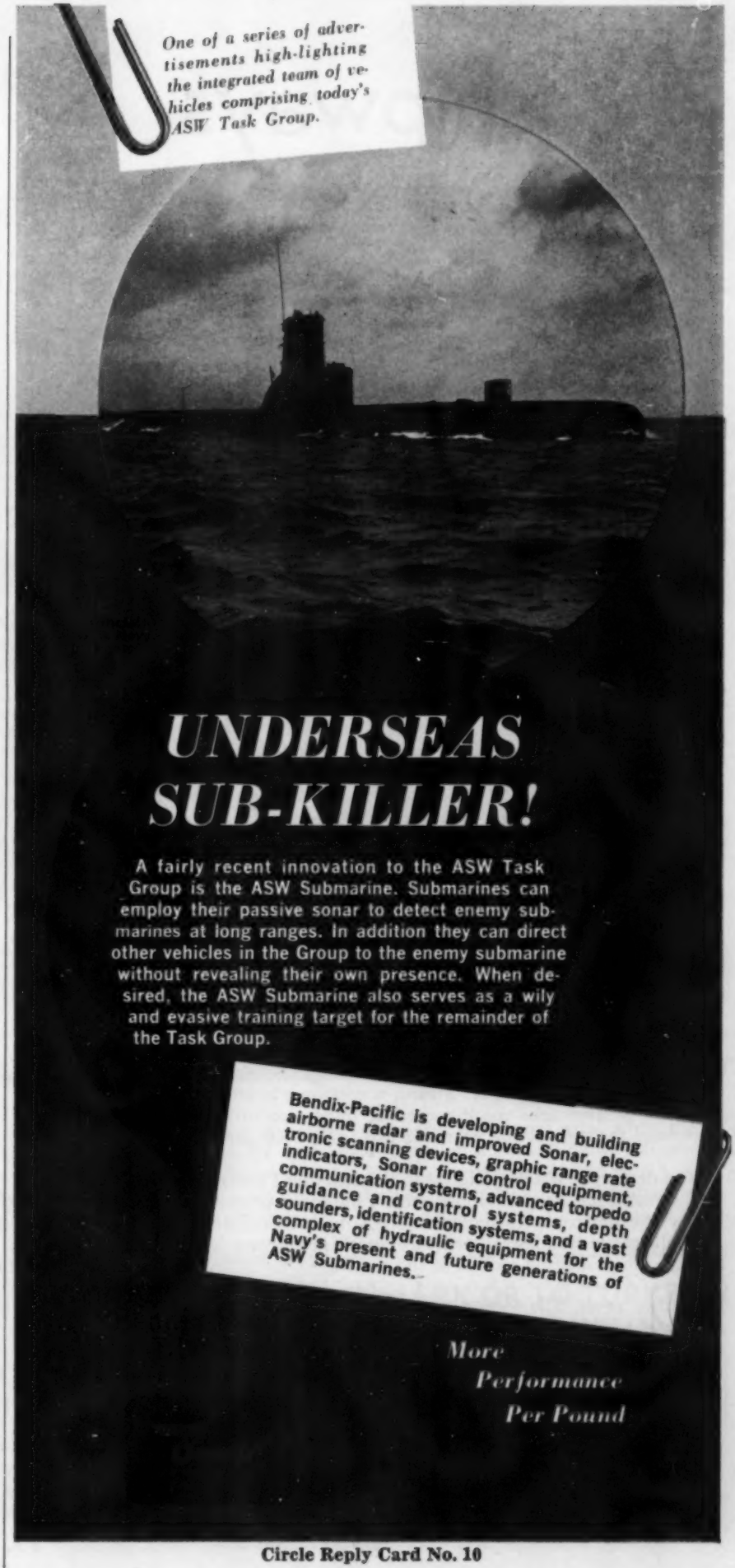
The USS *Albacore* (AGSS-569), the Navy's auxiliary submarine used to develop and test advanced hydrodynamic design features, will undergo her fourth conversion in fiscal 1961. The conversion job, also assigned to the Portsmouth yard, will cost $14 million. It will provide the *Albacore* with new motors, propellers and a long endurance silver zinc battery. These changes will increase her speed by at least 50 per cent at any depth, and enable her to maintain high speeds while submerged during research runs.

Conversion of fourteen of the *Gearing* 710 class destroyers is included in the fiscal 1961 program as a continuation of the Fleet Rehabilitation and Modernization (FRAM) program started last year. The modernization cost of each destroyer will be around $10.2 million. The FRAM work has been assigned to naval shipyards. The destroyers will be equipped with DASH, ASROC, long-range sonar, and other modernized ASW gear.

Atlantic destroyers due for FRAM work are the *William C. Lawe, Samuel B. Roberts, Power, Warrington, Joseph P. Kennedy Jr., Charles H. Roan, Charles R. Ware* and *Forrest Royal.* Pacific destroyers are *Theodore E. Chandler, Henderson, Hollister, Ozbourn, Arnold J. Isbell* and *Brinkley Bass.*

In addition to the ships directly associated with ASW, the new shipbuilding program also includes one conventional-powered attack aircraft carrier, five fleet ballistic missile submarines (including long lead-time items for seven POLARIS subs), one amphibious transport, dock, one fast combat support ship, one combat store ship, two large harbor tugs and 20 mechanized landing craft.

The importance of getting adequate ships for the Navy's ASW program was stressed by Defense Secretary Thomas S. Gates, Jr., during Congressional testimony on why the Navy rejected nuclear power for its new carrier. The Navy would have had to tag on another $130 million to the $293 million cost of the carrier if it had wanted nuclear propulsion. Mr. Gates bluntly declared, "It is a question of buying anti-submarine warfare capability instead of buying nuclear propulsion for the aircraft carrier."



One of a series of advertisements high-lighting the integrated team of vehicles comprising today's ASW Task Group.
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A fairly recent innovation to the ASW Task Group is the ASW Submarine. Submarines can employ their passive sonar to detect enemy submarines at long ranges. In addition they can direct other vehicles in the Group to the enemy submarine without revealing their own presence. When desired, the ASW Submarine also serves as a wily and evasive training target for the remainder of the Task Group.
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Circle Reply Card No. 10

# shipways

By William O. Foss

**Submarine overhauls will dominate the work schedule** of the Pearl Harbor Naval Shipyard from September until next July, reaching a peak in December when the yard will be working on six submarines at one time.

Starting in September the Pearl Harbor yard will be overhauling the *Medregal*, followed by *Bashaw* and *Tang*. The peak will be in December when the submarines *Grayback*, *Carbonero* and *Greenfish* enter the yard. The latter will be a Fleet Rehabilitation and Modernization (FRAM) overhaul.

Completing the submarine overhauls at Pearl in fiscal year 1961 will be the *Bluegill* and *Growler*, scheduled for overhauling next May. Last August the Pearl Harbor yard completed its overhaul work on the submarine *Wahoo*.

* * *

**First Navy ship to get a miniaturized automatic degaussing system** is the *Wahoo*. The new system was installed while the *Wahoo* underwent overhaul at Pearl Harbor.

The degaussing system will neutralize the submarine's magnetic field, making the ship operational in mined areas. To accomplish this, a rigid copper cable was wound around and into the pressure hull at predetermined locations vertically and horizontally. The cable was connected in proper polarity and energized to neutralize the magnetic field created by the ship. The Navy will make a thorough evaluation of the degaussing system before installing it on other submarines.

* * *

**Only two submarines have joined the "Ten Granders,"** a "club" for submarines making their 10,000th dive. Both subs joined the exclusive club this year. The *Spikefish* was the first to join, making her 10,000th dive March 18 off Key West. The *Sarda* made her historic dive July 12 in the vicinity of Block Island.

* * *

**The bathyscaph** *Trieste* is undergoing complete overhaul at the Navy Electronics Laboratory at San Diego. The 75-ton deep-diving submersible had been operating off Guam. After overhauling, the *Trieste* will be used in a series of dives off the coast of Southern California.

* * *

**Six escort destroyers of Destroyer Squadron 28** — an element of the Atlantic Fleet's adroit anti-submarine Task Group ALFA — have received the coveted Anti-Submarine Warfare "A" Award for fiscal year 1960. Winners were the *USS Waller* (DDE 466), *Conway* (DDE 507), *Eaton* (DDE 510), *Cony* (DDE 508), *Murray* (DDE 576) and *Beale* (DDE 471).

To be eligible for the "A" award, a destroyer must attain necessary exercise and performance merit scores. It must also turn in an excellent performance throughout the year as a screening ship and ASW attack ship.

* * *

**The destroyer** *Witek*, assigned to the Atlantic Fleet's Operational Development Force, has been equipped with a pump jet propulsion system that will allow the destroyer to operate quietly in submarine infested waters. The propellers run in a barrel structure which produces a jet-like effect in addition to the propelling motion of the screws.

* * *

Cruiser news: The *Providence* (CLG 6) is the first guided missile cruiser assigned to the Pacific Fleet. She'll be home-ported in Long Beach, Calif. The *Helena* (CA 75) is undergoing modernization in the San Francisco Naval Shipyard. She will be back in the Fleet in November.

* * *

**The slogan for Navy Day 1960** — October 27 — is "U.S. Navy—Flexible Force For Freedom." The Navy likes this phrase since it is new and euphonious, emphasizes the versatility of naval forces, and stresses the concept of mobility. Further, it calls attention to the fact that our Navy is more than a deterrent force, since it is dedicated to the attainment of our ultimate goal: freedom.

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underwater engineering

second issue Vol. 1, No. 2, 1960

# russia's assets in the 'wet war'

By William O. Foss

The American public might as well get used to hearing about Russian oceanographic vessels plying our coastlines. They have been doing that for a number of years, and their visits to our waters are increasing.

As a nation, whose history has always been based on terra firma, Russia has progressed rapidly when it comes to winning the struggle of the oceans.

Ten years ago the Soviet Navy ranked about ninth among world navies. Today the Soviet Navy ranks No. 2 to the U.S. Navy.

Her submarine force is the biggest in the world.

Soviet oceanography was in a provincial state about ten years ago. Today the Soviet oceanographic research program far surpasses that of the Free World.

The U. S. Navy recognizes the Communists' lead in oceanic studies: "Soviet effort in oceanography is massive, of a high caliber, and is designed to establish and demonstrate world leadership," states Vice Adm. John T. Hayward, Deputy Chief of Naval Operations for Research and Development.

In the Navy Seapower presentation, "The Conquest of Inner Space," we find this admission: "Today we trail the Soviets in numbers, tonnage, and quality of seagoing research ships; we also trail in manpower devoted to the job of exploring the seas; and probably in supporting facilities of all kinds."

Considering the growing size and capabilities of the Soviet submarine fleet, plus the benefits derived from concentrated and world-wide oceanic studies, the "wet war" — the oceanography race — may well determine the fate of nations and the human race.

Like the crash programs which produced the Sputniks and Luniks, the Soviet Union has accelerated its oceanographic studies.

The principal coordinating body for oceanography in the Soviet Union is the Oceanographic Commission of the Academy of Sciences. It oversees the marine studies of nearly 100 establishments, but the leading Russian oceanographic research institutions are the Institute of Oceanology of the Academy of Sciences, the State Oceanographic Institute of the Main Administration of the Hydrometeorological Service, the Marine Hydrophysics Institute of the Academy of Sciences, the Arctic and Antarctic Scientific Research Institute of the Main Administration of the Northern Sea Route, and the All-Union Scientific Research Institute of Fish Economy and Oceanography.

The number of Soviet oceanographers, including marine biologists and fisheries researchers, is estimated as high as 800 to 900. Many of their oceanographers are young,

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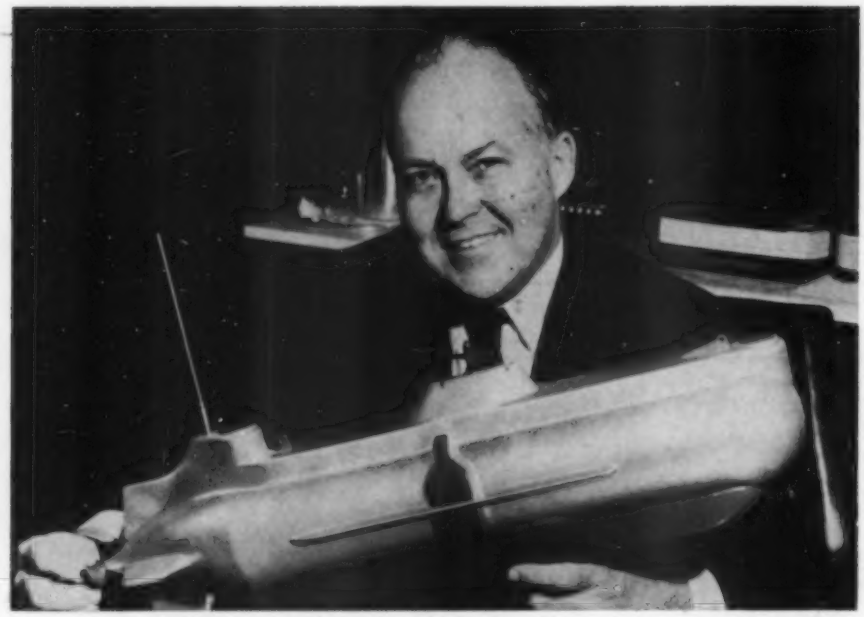
Germany began World War II with 57 submarines. She came close to winning that war by the destruction of allied shipping. Today the Soviet Union has 500 or more submarines. In a short time the ratio between these figures may reach ten to one. It could also mean ten times the World War II threat.

In discussing the new submarines of the Germans at the close of World War II, Winston Churchill declared: "This weapon in Soviet hands lies among the hazards of the future". Of course, we know the Russians took over many German submarines —completed or under construction— and with new construction the Red underseas fleet now represents the greatest submarine power in the world.

The tactics and problems of submarine warfare have changed somewhat since World War II. Subs are faster, can stay under water longer, can dive deeper and have better armament. Anti-submarine forces have better equipment and have made extensive efforts to develop better tactics and increase their training and over-all effectiveness. It remains, however, for a full-scale, detailed analysis to disprove an impression that, of the two competitive systems, the submarine enjoys the advantage. Many experts feel that it is the threat of the Soviet submarines that appears to be the controlling influence in the Communists' plans to isolate America from the remainder of the Free World.

*—Editor's note*



**U. S. Navy officials sought Federal funding for this undersea research vehicle, the Reynolds Aluminaut, which would fill a definite need in our race with the Russians. However, Federal budgeteers said no. So Reynolds is paying construction costs itself. Model is held here by J. Louis Reynolds.**

but they gain plenty of experience when placed aboard large ocean-going research ships.

The present research effort is oriented toward applications. Even the basic research conducted at the institutes of the Academy of Sciences tends to be directed toward ultimate applications.

An armada of more than 100 ships is available to Soviet oceanographers. This fleet was first developed by converting other ships, including a submarine and large cargo ships. As the Soviet oceanic research studies progressed, so did the ships serving these studies. The most modern of these ships is the *Mikhail Lomonosov*, which was constructed especially for oceanographic research in the Neptun shipyard at Rostok in East Germany, and which recently operated off the East Coast of the U.S.

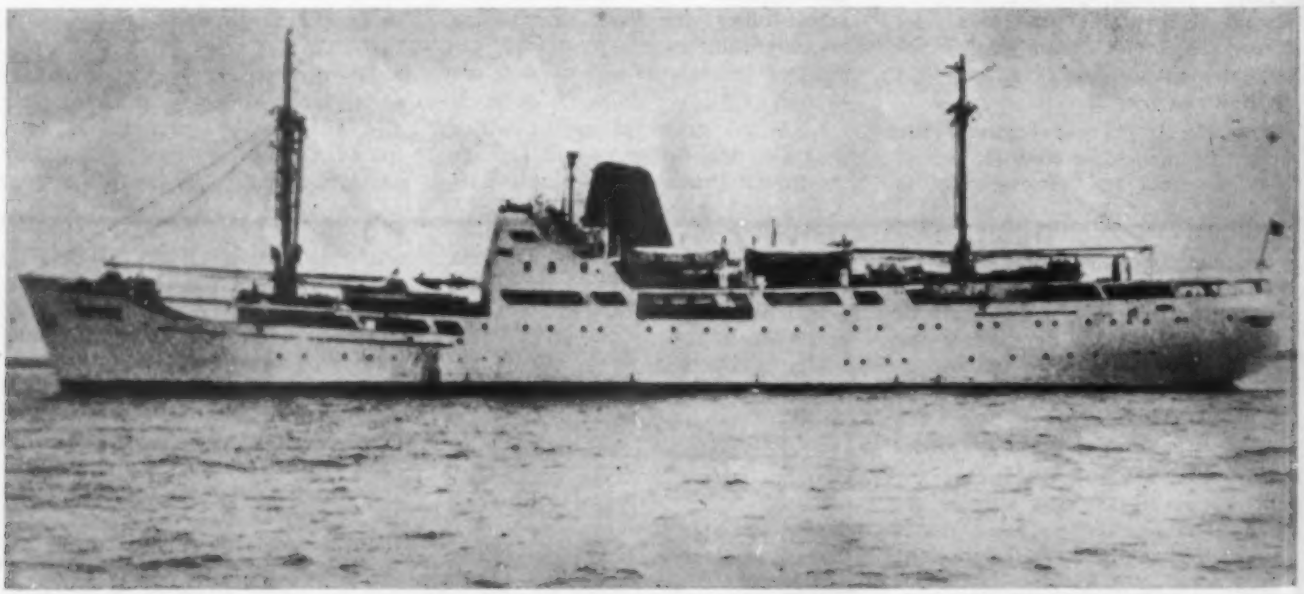
Each of the major Russian oceanographic research institutions has its work cut out for it. Following is a brief review of the scope of their studies:

**The Institute of Oceanology of the Academy of Sciences —** The Institute is responsible for the complex study of the sea and oceans. Founded in 1946 from the Laboratory of Oceanography, the Institute is subordinate to the Department of Geological and Geographic Sciences of the Academy of Sciences. Located at Moscow, it maintains stations near Baku on Artema Island in the Caspian Sea and near Gelendzhik on the Black Sea. Headed by V. G. Kort, the Institute has a staff of more than 500, including about 120 scientists. Ships assigned to the Institute include the *Vityaz*, *Geolog*, *Akademik Vavilov* and *Akademik Shershov*.

The Institute is responsible for the study of the physical, chemical, geological and biological characteristics and processes occurring in the oceans. It is also responsible for the study of the water level of the Caspian Sea.

**The Marine Hydrophysics Institute of the Academy of Sciences —** Responsible for the study of physical and dynamic oceanography, the Institute was organized in 1948 by combining the Black Sea Hydrophysics Station at Katsiveli in the Crimea and the Marine Hydrophysics Laboratory in Moscow. It is subordinate to the Department of Physico-Mathematical Sciences of the Academy of Sciences. Work is conducted on wave research, the thermal regime of the sea, and the interaction of oceans and continents. The main Institute is located at Moscow and the Black Sea station near Simeiz, Katsiveli, Crimea. The oceanographic research ship *Mikhail Lomonosov* serves the Institute.

**The State Oceanographic Institute of the Main Administration of the Hydrometeorological Service —** This Institute is principally concerned with the waters immediately adjacent to the USSR. Formed in 1943, the Institute is located in Moscow



**Soviet oceanographic research ship Mikhail Lomonosov, which recently operated off East Coast of U.S.**

with a branch at Leningrad and a laboratory on the Caspian Sea. The Moscow staff totals about 200, while 100 serve at the Leningrad branch.

Most of its research activities support the economics relating to the fishing industry, the merchant marine and the oil industry. Facilities of the Institute includes the research vessels *Professor Rudovits* and *Okeanograf* and a 32-component Doodson tide machine.

In addition to its theoretical investigations in physical and dynamic oceanography, the Institute publishes books and tables, and prepares oceanographic forecasts.

**The Arctic and Antarctic Scientific Research Institute of the Main Administration of the Northern Sea Route** — A Department of Oceanology within the Institute concerns itself with all aspects of oceanography of the polar regions, including the study of sea ice. It is also responsible for observing and predicting sea ice and its movement. The Department of Oceanology and the main Institute are located in Leningrad. Some 125 to 150 persons serve the oceanology department. A small laboratory in Moscow is maintained for routine chemical, physical and geological studies. The icebreakers *Ob* and *Lena*, which also double as oceanographic research vessels, are assigned to the Institute. Other Institute ships are the *Fedor Litke*, *Biu*, *Aktyubinsk*, *Toros*, *Polyarnik* and *Lomonosov* (not the *Mikhail Lomonosov*, but a smaller, older vessel).

**All-Union Scientific Research Institute of Fish Economy and Oceanography** — Originally organized in 1933, the Institute has undergone a series of administrative changes. The main Institute is located in Moscow and is subordinate to the Ministry of Fish Industry. It has regional affiliates in Murmansk, Kaliningrad and the Far East. Most of its research is routine oceanographic surveys in support of existing fishing areas and in the development of new ones. The converted submarine *Severianka* does oceanographic research work for the Institute.

Let us take a look at the major Russian oceanographic research ships and the work they have done and are doing in the world's oceans:

The *Severianka* — The first submarine in the world to be used solely for oceanographic research. She is, however, equipped mainly for the study of fish movements in the oceans for the purpose of assisting fishing fleets. The benefits of her oceanographic studies cannot be overlooked.

Among the features of the *Severianka* are special portholes and powerful searchlights for underwater observation. Schools of fish are first located by sounding devices, then observed through the portholes. The sounding devices operate both downward and upward.

Included in her many instruments are an underwater television camera, which makes it possible to see what is going on ahead along the course. Other instruments include apparatus for measuring underwater currents, bottom soil samplers, temperature readings of the water, measurement of light and percentage of oxygen content in sea water.

Also included in her extensive gear are photographic equipment for shooting both still and motion pictures of underwater life.

The rebuilt Russian navy submarine has a tonnage of 1,050. Her first study trip was in the Barents Sea in 1958, followed with oceanographic expeditions into the fishing areas of the Atlantic Ocean.

*Mikhail Lomonosov* — This 5,960-ton oceanographic research ship, which operates primarily in the Atlantic Ocean, is the pride and joy of the Soviets' oceanography fleet. Completed in August 1957, the *Mikhail Lomonsov* visited New York in 1959 in connection with the meeting of the International Oceanographic Congress. Her complement normally numbers 132, with scientists slightly outnumbering sailors, 67 to 65.

Americans who visited the *Mikhail Lomonosov* said she was well equipped with modern oceanographic research instruments. Among her equipment are radar gears of advanced design, elaborate radio communications facilities, and a British-built loran navigation aid.

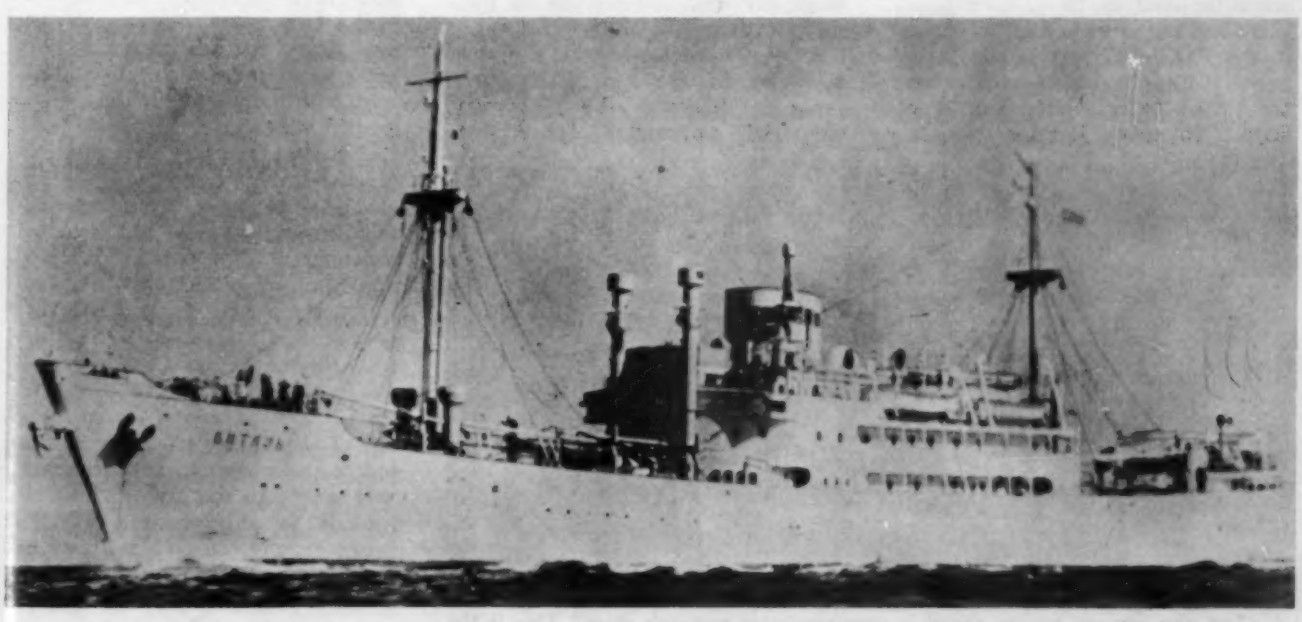
When U.S. Navy planes flew close to the *Mikhail Lomonosov*, she was engaged in studies of the Gulf Stream currents and their influence on navigation, fishing, and the climate, according to Soviet reports.

Among the observations made during recent Atlantic visits by the *Mikhail Lomonosov* are these:

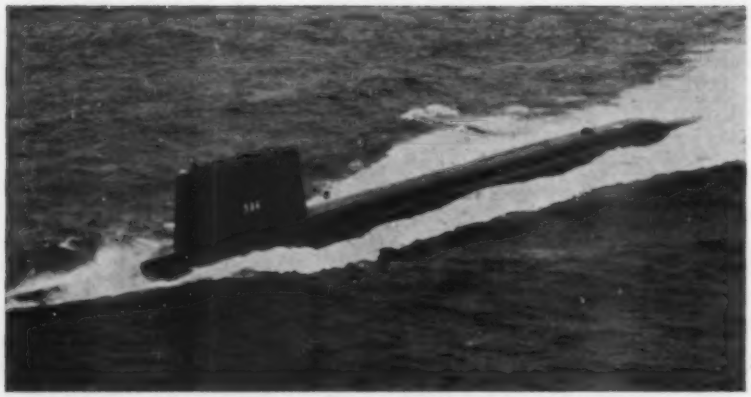
1) Fluctuations in the North Atlantic currents and their effect on the climate in Europe and the northern waters.

2) Chemical identifications of the ocean water.

3) Discovery of three underwater



**Vityaz, flagship of the Soviet oceanographic vessels in the Pacific. Crew of 64 is outnumbered by scientific staff of 73.**



**The United States may be far advanced in modern submarines . . .**

peaks between England and the United States. These peaks, ranging from 650 meters to 4,000 meters, were not marked on any known maps, the Russians claim.

4) Foreshadowing the entrance in the Atlantic waters of more Russian fishing vessels, the *Mikhail Lomonosov* has reported new promising fishing areas in the northwestern Atlantic.

5) "We discovered that the waters of the Atlantic were polluted by radioactive waste," wrote the *Mikhail Lomonosov* scientists in a report to their home office, the Marine Hydrophysics Institute of the Academy of Sciences. The ship scientists said they had discovered that radiation is not only on the surface but carried by many thermic currents down to a depth of 200 meters.

*Vityaz* — Flagship of the Soviet oceanographic vessels in the Pacific Ocean, this 5,546-ton ship is a converted cargo diesel ship. She joined the oceanic studies in 1949 after being completely overhauled to accommodate a crew of 64 men and a scientific staff of 73.

During her oceanographic studies in the Pacific as part of the International Geophysical Year program, the *Vityaz* twice visited San Francisco. Thirteen Russian oceanographic research vessels participated in the IGY oceanography program.

While sailing in the Pacific during the IGY program, the *Vityaz* sounded a record depth of 35,948 ft, off the Philippines in August 1957; discovered a 20,340-ft depression in the ocean floor north of the New Hebrides Islands; and brought to the surface from depths of 35,000 ft several previously unknown species of sea animals.

Later, in March 1959, the *Vityaz*, investigating the Marianas trench in the Western Pacific, recorded a record depth of 36,173 ft.

Like the *Mikhail Lomonosov* scientists, oceanographers aboard the *Vityaz* showed concern about using the ocean as a dumping ground for atomic fission wastes. Research by the *Vityaz* showed that Pacific waters are in continuous movement. This makes it "inadmissible" to pollute the deep waters of the Pacific with atomic waste, wrote the *Vityaz* oceanographers.

*Ob* and *Lena* — These are 12,000-ton ice-breaking diesel cargo ships originally designed for use on Russia's northern sea route. They have been converted for oceanic research, and give the Soviets an excellent capability in polar seas.

The *Ob* supports the Soviet Antarctic expedition, and her scientists have studied the interaction of Antarctic waters with the waters of the Atlantic, Pacific and Indian Oceans.

During her Antarctic travels, the *Ob* discovered a volcanic mountain range rising nearly 10,000 ft above the bottom of the Pacific Ocean between Antarctica and South Africa.

Manganese ore in the ocean bottom deposits were found in the Tasman Sea and Pacific Ocean by the *Ob* scientists.

The *Ob* has also studied the flow of ice off East Greenland in connection with research work for forecasting the sailing conditions of the Northern Sea Route.

The *Ob* is equipped with a helicopter landing platform.

*Zarya*—This three-masted schooner of 580 tons is the only non-magnetic ship in the world, according to Soviet claims. She has sailed in the Atlantic, Indian and Pacific Oceans, proving data for updating contemporary magnetic charts. Substantial anomalies have been reported by the *Zarya*. Aside from aiding surface navigation, such data is useful for determination of mine fuze settings and for missile guidance and control.

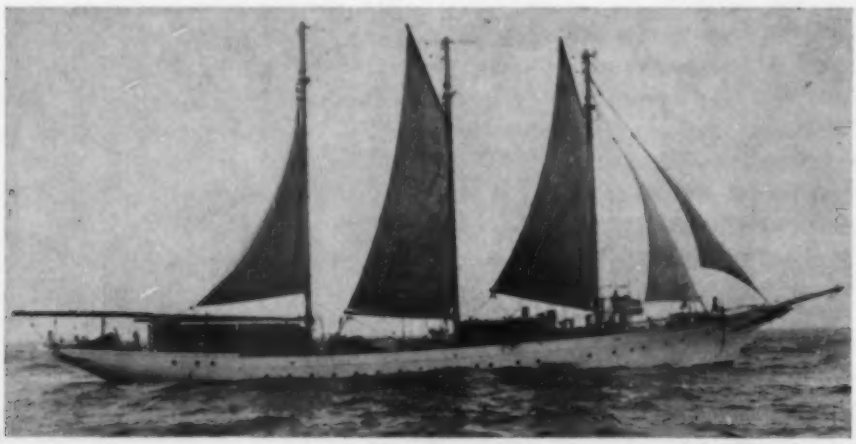
Other Russian oceanographic research ships include the *Voyeikov*, which also has made meteorological studies in the Sea of Japan; the *Sedov*, another sailing ship, which was recently sighted about 300 miles south of Augusta, Me.; the *Ungo*, which was shot up by a trigger-happy North Korean gunboat (the Reds claimed a South Korean navy ship did the shooting).

Among heavyweights in the Russion oceanographic fleet are the *Pole*, 5,000 tons; *Sevastapol*, 3,000 tons; *Diamond*, 1,500 tons; *Ekvator*, 1,500 tons; and *Okean*, 3,000 tons.

In addition to the many oceanographic research vessels, the Soviet Union can also count upon a number of ever-growing and well-equipped ocean-going trawlers. These trawlers are known to be equipped with oceanographic research equipment, and they are often sent on surveys in waters where it is not expedient to send the larger ships.

While the Soviet Union does not yet have a bathyscaph like the U.S. Navy's *Trieste*, reports from Russia tell of the Soviet scientists building both smaller and larger bathyscaphs.

It is obvious that the Soviet Union intends to stay in and excel in oceanography for both military and economic reasons.



**. . . but who can say we are ahead in oceanographic research ships? This is the Vema, owned and operated by Columbia University.**

# how to train new oceanographers

By Gordon A. Riley
*Yale University*

Before we can discuss education and manpower problems in oceanography cogently, we must consider what oceanography is and what the requirements are for productive work in the field. Oceanography may be roughly defined as the application of certain basic disciplines — mathematics, physics, chemistry, biology, and geology — to any and all oceanic problems. We can broaden the definition slightly by adding that certain other interdisciplinary fields such as meteorology, geophysics, geochemistry, and limnology have made important contributions both to the intellectual content of oceanography and to its manpower.

Oceanography, then, is an applied science in the fundamental sense of the term. Suppose, for example, that a geneticist working with a marine species finds that his material comprises several different strains. He might isolate these strains genetically and examine their slightly different physiological properties. We would not tend to call this man an oceanographer, although he happens to be working with a marine animal. We might call him a marine biologist. He might even be employed in an oceanographic laboratory on the grounds that his work is potentially useful to oceanographers. Suppose now that this man becomes curious as to whether his strains, with their slightly different physiological tolerances, can explain a rather spotty and discontinuous distribution of the species in nature. To pursue this problem he will have to investigate certain aspects of the marine environment — perhaps the seasonal temperature cycles in the various localities where his species is found, perhaps salinity distribution, perhaps he must investigate the natural food of his species and its regional variations, and so on. This is biological oceanography. And it is characteristic of the subject as a whole, as well as the hypothetical example, that oceanography has a content of its own, of facts and interrelationships that cut across the lines of the basic disciplines and which must be mastered before oceanographic problems can be undertaken effectively.

Thus the growth of oceanography proceeds by two processes. One is the development of oceanographic theory and knowledge, per se. The other is the seeding into its content of new concepts that arise in the basic sciences. Without the latter, oceanography undoubtedly would become sterile sooner or later.

Ideally then, a prospective oceanographer attains thorough grounding in a basic science of his choice and as much knowledge of the others as he can acquire within the framework of ordinary academic training. To this is added, usually at the graduate level, professional training in oceanography.

In practice, training methods have varied widely and still do. Until the late prewar years there were few formal courses, and no degrees were offered in the subject. Manpower was recruited from the basic disciplines, and oceanographic training was a do-it-yourself project. Thus when the Woods Hole Oceanographic Institute was founded in the early 1930's, there were only two staff members who had had extensive oceanographic experience. The others were recruited from basic disciplines in the universities. But within two years after occupancy of the plant, the first volume of collected reprints was distributed, containing papers of good oceanographic quality. By modern standards this is not the most efficient way to produce oceanographers, but it was continually done in those days, and indeed many men are still recruited who have little or no academic training in oceanography.

In the early postwar years the number of universities offering graduate degrees in oceanography increased from three to 11. Fleming (1957), in a paper entitled "Present Status and Future Development of Oceanography," listed an additional 15 universities providing education of one sort or another in oceanography but not granting a degree in the subject.[1] The roster has not increased substantially since then, although the number and quality of course offerings have improved.

At the present time the type of graduate education varies widely. Universities offering a degree in oceanography generally list some five to 15 formal courses in addition to thesis work. Others offer a degree in a basic discipline, with the oceanographic program consisting of two or three courses and thesis supervision. Quoting from chapter 8 of the report of the National Academy of Sciences Committee on Oceanography:

"Opinions differ as to whether the major emphasis at this level of training should be on the basic discipline or on the more specialized professional aspects of oceanography. Thus, the young oceanographer is not a standardized product. This is probably a healthy situation in any interdisciplinary profession, leading to diversification of knowledge, interests, and technical skills. However, it must be admitted that thorough education in both oceanography and basic science cannot be accomplished within the usual span of graduate study. Postgraduate study and on-the-job training are necessary."[2]

Fleming (1957) listed 18 universities that offer one or more undergraduate courses in oceanography. Only one grants a bachelor's degree in the subject. Most oceanographers feel that there is potential danger in specializing so early and that the best men should not be urged to embark on such a course. However, if the student goes on to a Ph.D. in the same subject, and if he has full realization of the need for a well-rounded course in the basic disciplines as well, the results may be excellent.

The quantity of oceanographers that is being produced is small and by no means meets the current demand. The questionnaire distributed by Fleming (1957) showed that in the five-year period from 1949 to 1953, 29 Ph.D.'s were granted and 98 M.S.'s. There is no record of the number of oceanographers that were recruited from basic disciplines with limited training in oceanography or none. Probably the number exceeded those with full professional training. Nor is there more recent information available, pending completion of a survey now underway under the direction of the Committee on Education and Recruitment of the American Society of Limnology and Oceanography. At the moment we can only say that recruitment needs to be increased in order to supply present and expected future needs. Doubling the oceanographic manpower during the next ten years, as recommended by the Committee on Oceanography of the National Academy of Sciences, would require an

average output of 80 oceanographers per year.

One difficulty in expanding training programs is that the pursuit of oceanography as a research subject is not entirely compatible with teaching. This is partly due to the obvious difficulty of scheduling course work and seagoing operations so that they do not seriously conflict. Either an instructor must limit himself to short cruises in coastal waters or he must have frequent leaves of absence for more extended sea duty. As far as the university is concerned, this kind of teaching is expensive, since the course load of an individual instructor is likely to be less, on the average, than in the more stereotyped departmental program. Also buying and operating a research ship is regarded by many universities as prohibitively expensive. There are, as a matter of fact, only five universities that operate large ships suitable for deep sea research. The remainder have smaller vessels, or none, and their students are deficient in this practical aspect of their training.

One of the most pressing needs of the small university laboratories is for growth and diversification of their staffs. These small laboratories consist almost entirely of biologists and biological oceanographers. They have learned a few techniques of physical and chemical oceanography to supply background for biological studies and to give breadth to the training of young biological oceanographers. They do not have the necessary background to produce physical oceanographers. This is particularly unfortunate since the greatest shortage is in the physical branch of the subject.

Some large, nonuniversity laboratories, of which the Woods Hole Oceanographic Institution is an outstanding example, are keenly aware of these problems and have made a sincere effort to permit their staff members to accept part-time teaching posts in universities and also to provide subsidiary training for visiting graduate students ashore and afloat. These efforts are praiseworthy, but have been only partly successful. Teaching efforts by their staffs at distant campuses seriously interfere with research programs, and opportunities for student training cruises often do not arise at times that are consistent with academic programs of the students.

We find then that out of a total of 400-odd Ph.D.'s in the oceanographic community, not more than about 50 are actively engaged at any one time in the academic training of the younger generation. Their efforts are hampered by lack of diversification of their staffs and by poor physical facilities. These handicaps probably cannot be removed except by liberal infusion of Government money in the form of basic institutional support.

Let us turn now to the matter of recruiting graduate students in oceanography. We must admit at the outset that certain requirements for a successful oceanographic career tend to set it apart from other scientific endeavors. The average oceanographer will spend a tenth or two-tenths of his life at sea — probably more than this at the beginning of his career, and less as advancing years bring increasing teaching and administrative duties. He will do his work under conditions that often are uncomfortable and seldom are optimal for scientific manipulations. He sometimes will be separated from his family for considerable periods. He needs to have physical and mental aptitudes that make this kind of life attractive or at least tolerable.

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*This paper was presented at the Eighth Conference on Scientific Manpower and is reprinted with permission from a report on the Conference published by the National Science Foundation in June 1960.*

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Every oceanographic laboratory must have a hard core of these seamen-scientists, although there are also niches for people who seldom if ever go to sea—theoreticians, taxonomists, and so on.

Thus the prospective candidates who come to us are a selected group of people who think they would like this kind of life. In all fairness we give them some seagoing experience as soon as possible so that they can confirm their choice or change their minds.

If you were to inquire around the country whether we are getting enough candidates of the right kind, opinions would vary from one laboratory to another. Perhaps the best general answer is obtained by considering again the placement of the finished product. To those of us who are hiring oceanographers or placing our Ph.D.'s it is quite apparent that there is a shortage, varying from slight in the biological branch to extreme in physical oceanography. We could profitably produce more and shall have to do so if the field is to expand. However, I see no real difficulty in expanding the training program gradually, other than the problem of financial support.

In discussing the careers and problems of graduate students I shall first talk about what I know best—namely, the situation in my own university. In the broader outlines it is typical of the countrywide situation, except where otherwise specified later.

We happen to be one of the universities that grant a degree in a basic discipline rather than in oceanography, per se, and with rare exceptions we have only doctoral candidates. Virtually all of our students are aiming for a career in biological oceanography.

Requirements for admission include college courses in physics, calculus, organic chemistry and its prerequisites, and a solid undergraduate major in biology. Any deficiencies in these requirements must be made up early in the graduate career. The student then goes on to formal graduate courses and examinations in the department of his choice. He takes a course in oceanography and one in ichthyology that are given by the staff of the Bingham Laboratory, but are nominally part of the graduate curriculum of the zoology department. These are followed by a series of informal seminars in various specialized aspects of the subject.

Thesis supervision is jointly administered by the Bingham Laboratory and the department in question. In some cases there have been interdepartmental degrees when the thesis cut across the lines of the disciplines. About half of our students do their work in local waters where we operate a small, continuing oceanographic program. If a man wants to join an expedition or go to another oceanographic institution to collect thesis material, we try to make this possible, provided he has developed to a point where we feel he is able to work effectively with little or no direct supervision. Thus in recent years we have had dissertation problems in such diverse locations as the Arctic Ocean, Bermuda, and the west coast of Peru. A recent and growing development is for junior staff members of nonteaching laboratories to come to us on leaves of absence for formal academic training, bringing with them thesis material that they have collected as part of their job.

There are two main points to be made in connection with this recital. One is that our requirement for advanced knowledge of both a basic discipline and oceanography is a more arduous task than that of most other graduate students. In the second place, a dissertation based on field collections is likely to be more

time-consuming than laboratory studies. This is particularly true when the research is done on an expedition. As a result it tends to be a long course of study. None of our students has completed a Ph.D. in less than four years; five or six is a more usual number, and occasionally it is as much as seven.

In universities that have departments of oceanography the situation is not very different. There are more courses in oceanography and less work in basic disciplines, but the latter cannot be neglected. Young men who are not well prepared at the undergraduate level may have to spend a year or two acquiring the necessary background before specializing in oceanography.

In our university there are three main avenues of financial support. The majority of students earn their living as teaching assistants in their department. Then there are research assistantships. These are mainly derived from grants and contracts obtained by departmental staff members, most of them from Federal sources of one sort or another. Thirdly, the top 10 per cent, more or less, can win fellowships from the university or from several Government agencies.

All of these sources provide a rather minimal wage. It can support a single man. A couple can live in reasonable comfort if the spouse has a job. A man with family responsibilities is heavily handicapped if not entirely excluded unless he has an independent source of income. A man who acquires family responsibilities during his student career is automatically sentenced to a long and difficult period during which his studies suffer while he spends most of his time earning a living.

These difficulties are, of course, common to all of the disciplines. The American system of higher education has turned all of our graduate students, supposedly of our intellectual elite, into second-class citizens for the duration of their period of study. If it is worse for prospective oceanographers, it is only because their term of study tends to be somewhat longer than that of some other disciplines.

In certain other respects the support of prospective oceanographers creates special problems. It has been pointed out that a number of universities have departments of oceanography which are exclusively graduate departments. Their students thus are blocked off from the major source of ordinary university support; namely, teaching the undergraduates in their departments. Their only support then is fellowships or research assistantships. Frequently the latter require more time than teaching assistantships. It is argued that such jobs in themselves constitute good training for their profession, which may be quite true in many cases. Nevertheless, from the students' point of view it is undesirable to prolong this period of penurious existence.

Then there are the students whose thesis research requires extensive fieldwork away from the university. This precludes their support by either teaching or research assistantships. Some few are able to get fellowships from one or another Federal agency. Support for the others must be found in some other way, if at all, often with considerable sacrifice of private university funds that we can ill afford to spend in this way.

The Committee on Oceanography was well aware of all of these problems and felt that any significant expansion of present training programs would require an increase in outside support, particularly with respect to fellowship aid and money for additional staff positions. Specifically we recommended a sum of $300,000 per year to be used to support fellowships at an annual rate of $3,500 to $4,000 per year, and an additional $500,000 per year for expansion of teaching facilities. We suggested that the funds be administered by the National Science Foundation.

These recommendations were embodied in a bill that was introduced into the House of Representatives by the Honorable Mr. Brooks of Louisiana as H.R. 6298. A hearing was held on August 24, 1959, by the Subcommittee on Geophysics of the House Committee on Science and Astronautics. At the hearing this bill was opposed by NSF on the grounds that it was against their policy to support fellowships for any specific discipline. Moreover, our purposes would be served if the basic stipend were lower but carried a substantial dependency allowance.

I appreciate the NSF point of view. There are certain dangers in singling out a particular discipline for special favor. Those of us who have been trained in the university tradition tend to feel rather strongly that all kinds of scholarly endeavor are to be equally respected and supported. Nevertheless the present system has not solved our problems, and a change is in order. Whether it be the kind recommended by the Oceanography Committee or some other policy change more palatable to NSF is immaterial if it solves our problem.

A satisfactory alternative solution could be obtained if NSF were granted additional funds for fellowships and if they simply recognized the fact that a problem exists and that something should be done about it. Let me explain what I mean in some detail so that there will be no misunderstanding.

NSF bestows fellowships on the best students. Experience has shown that there is no point in recommending a student for one of these fellowships unless he ranks in the top 10 to 20 per cent of his class. The remainder, though virtually ineligible for this kind of support, are, nevertheless, competent people who have a useful career ahead of them as scientists. We try to pick graduate students with a promising future, and we examine them carefully during the first two years to weed out any wrong choices. It would be harmful to our reputation and would be no kindness to the students to retain any whose scientific potential seems to be poor.

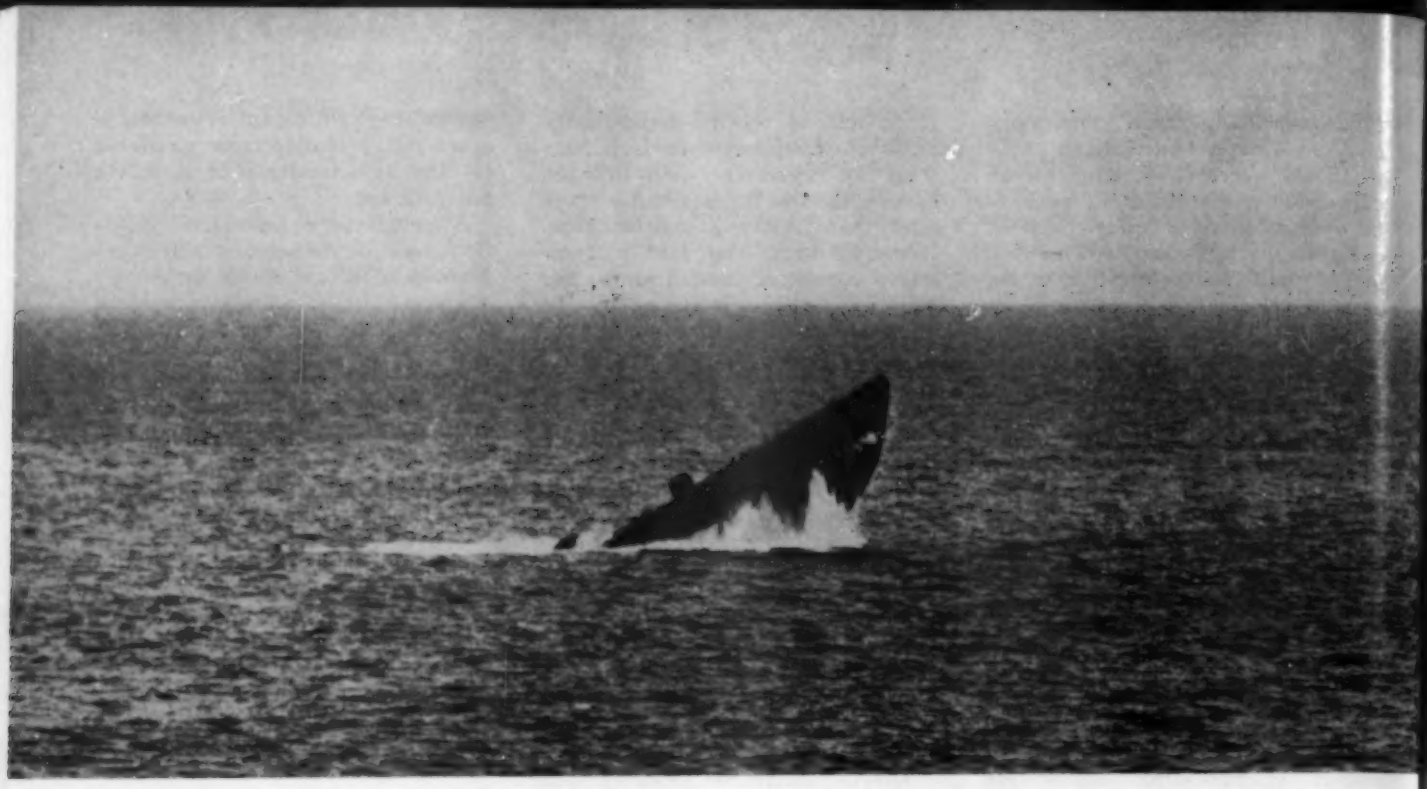
It is among these advanced students, who are tried and competent although admittedly not of the top rank, that the problems I have mentioned are well-nigh insoluble. This is no time for them to abandon a promising career because of suddenly increased family responsibilities. Nor should a man be forced to abandon plans for an interesting thesis problem in a remote location or in a non-teaching laboratory simply because he has to stay on campus in order to earn his living.

Problem cases exist in all disciplines, although as I have indicated they are intensified in interdisciplinary fields. Thus I am not pleading for a special field, but rather am asking for a general liberalization of NSF policy so that human needs can be considered wherever they exist. I submit that any competent graduate student should be eligible for support when this kind of special need can be established. Admittedly this puts a heavier burden on NSF in judging applications and distributing funds fairly. But it is only by some such means that we raise our graduate students to the status of first-class citizens.

## References:


1. Fleming, R. H., "Present Status and Future Development of Oceanography." 1957. Proc. 8th Pac. Sci. Cong., 3A:1177-1196.

2. National Academy of Sciences-National Research Council. Committee on Oceanography. Oceanography 1960 to 1970. 8-Education and Manpower. Chapter of a report in progress by the Committee on Oceanography. 1959. P. 1.



# computing hazards of nuclear attack

**By H. Burke Horton**
***Remington Rand Univac***
***(Formerly with the Office of Civil and Defense Mobilization)***

In many important research areas, direct experimentation is becoming increasingly difficult. This trend began before World War II, and it is well illustrated by the costs of making statistical tests on the accuracy of American bombsights during World War II. The requirement that plane, crew, and bombing range test each bombsight caused each statistical test or observation to become very costly. However, clever statistical procedures for extracting the maximum amount of information from limited observations made possible the solution of the problem at reasonable cost.

A similar example occurs in case of tests or experiments that require destruction of the sample. If every cartridge in a lot is fired, an excellent and complete report can be written about the quality of ammunition in the lot. Unfortunately, this leaves no ammunition. Statisticians have solved this problem by developing very excellent sampling techniques, procedures, and rules for quality control. As a result, the quality of ammunition during World War II was held at very high levels on the basis of tests that destroyed only a fraction of total output.

The trend toward higher costs of tests and experiments has continued for the last two decades. Since the war, the costs of testing nuclear weapons, reactors, long-range missiles, and space vehicles have risen to such high levels that each statistical observation costs many millions of dollars. Beyond even these costly experiments, there are cases in which the cost has become infinite. For example, we are now quite interested in such things as the physical processes in the interior of the sun, and the physical phenomena that could account for the complete life cycle of a star extending over billions of years. Clearly these experiments have an infinite cost, and yet we have an increasing interest in running such experiments.

The nuclear age has brought about certain contingent events for which the experiment costs, while not infinite, are unacceptably high. For example, we would like to know, and consequently we would like to have experimental data on, the effects of an all-out nuclear attack on a large, modern nation such as the United States. The unacceptable cost of one direct observation in studying such a problem would be many millions of lives, the loss of decades of progress and capital accumulation, the devastation of a large and valuable part of our planet, and some adverse effects on the health and well-being of all future inhabitants of the planet. Fortunately, by proper use of electronic computers, it is possible to gain considerable insight into the probable effects of nuclear attack on the United States by *simulating* such attacks. Many such attacks have been simulated and analyzed by the National Damage Assessment Center, Office of Civil and Defense Mobilization (OCDM).

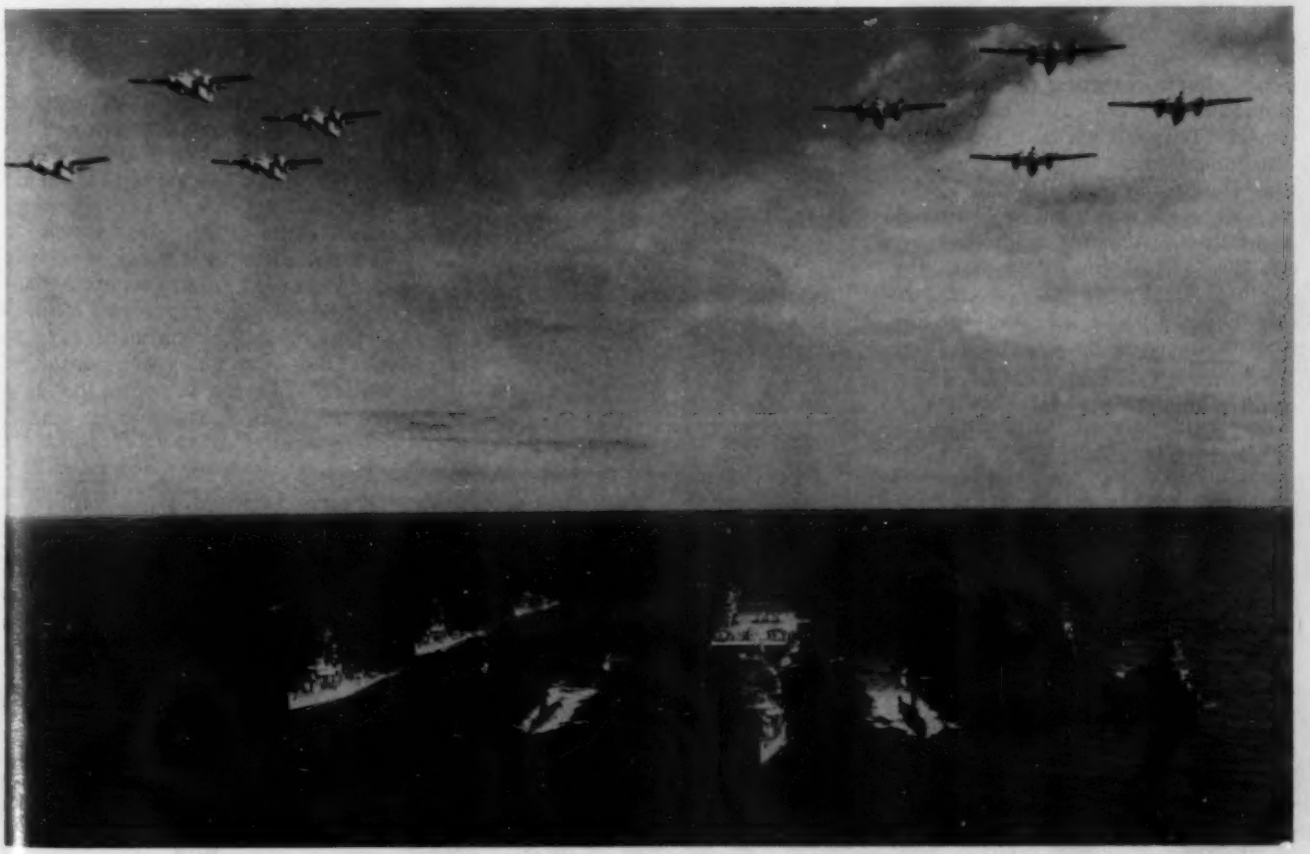
This article will not be a discussion of results, findings, or recommendations concerning American vulnerability. Much of such information is highly classified. What is presented here is an unclassified discussion of the techniques which permit analysis of the vulnerability of the United States to nuclear attack. The methods used are of interest to computer users because they illustrate a method of attack on the increasingly important class of problems in which direct experimentation is either impossible or not permissible.

Traditional mobilization planning in the United States, from 1917 to about 1945, consisted of detailed plans and programs for diverting the vast stream of American production from peacetime products and services to the requirements of war. A period of many months or several years was found to be necessary to accomplish such a large-scale diversion of national resources. The administrative machinery for implementing this kind of economic and industrial transformation was highly developed in the United States by 1945. It is worthy of note that the United States, as a democracy, succeeded in making a more complete diversion of peacetime resources than achieved by its totalitarian opponents. This diversion of industrial might was the basis of victory in World Wars I and II.

With the detonation of the first nuclear weapon, scientists throughout the nation realized that ultimately our immunity to large-scale destruction would disappear. However, for a time everyone was optimistic. Some felt that there would be no more wars; others felt that many decades would be required for any other nation to duplicate the Manhattan Project. Optimism on both counts was canceled in the late 1940's and early 1950's by technical, military, and political events which are familiar to all. By the early fifties, it was clear that the United States could be damaged. The only questions that remained were: 1) how much, 2) what could be done about it, and 3) what changes in mobilization plans and basic policies and procedures of mobilization planning were necessary.

It is not necessary to retrace the steps taken during the late fifties, but it is now generally recognized that there have been two principal changes in our thinking and in our preparations: 1) forces in being, required for deterrence and possible retaliation, now take precedence over a professional nucleus for a slow military build-up, and 2) the non-military resources of the nation must be geared to survival planning and long-range recovery, rather than support of an extended military effort.

The analytical techniques required for study of the effects of nuclear attack on the country are basically very simple. A library of



**Task force ALFA — a strong U.S. deterrent force.**

all major resources of the United States has been accumulated and stored compactly on magnetic tapes. This library contains information such as to type, exact location, amount, physical vulnerability, and detailed classification of resources. Coverage includes each census tract of all the large cities of the United States, as well as every urban place and, in effect, statistical coverage of every individual. Every manufacturing plant with 100 or more employees has been pinpointed and included in the resource library. Every important rail-classification yard, power-generating station, air field, dock, bridge, tunnel, university, water-control or pumping station, pipe-line station and the like, has similarly been pinpointed and included in the library. By statistical techniques, all the land in the United States, the livestock and principal crops, are covered. Overall, something on the order of 300,000 to 400,000 points are required for this extensive coverage of about 100 major classes of domestic resources.

In addition to resource coverage, tables of weapons effects have been compiled, based upon tests in Nevada and in the Pacific. These tables cover blast and thermal effects for a wide variety of yields, with scaling parameters for interpolation and extrapolation. Mathematical models of the fallout of radioactive debris from the large mushroom clouds resulting from nuclear detonations have also been prepared. These models take account of the distribution of debris within the cloud, the particle sizes, rates of fall, and statistical approximations to currents in the atmosphere. On the basis of this information, the mathematical model gives a measure of the time of arrival and the intensity of radiation resulting from each weapon over an area extending hundreds of miles downwind. The overlapping effects of numerous weapons affecting a given area are accumulated in the computation process.

From biological experiments, the effects of radiation on living resources have been estimated. These include acute effects such as death and radiation sickness, and then, by rather tenuous extrapolations, long-term effects involving such things as directly accelerated mortality (through exposure), land contamination, and resulting indirect effects on livestock, crops, and the population.

In order to make realistic estimates of the possible weight and distribution of attacks, gaming techniques have been devised for the statistical translation of gross attack plans into realistic attack patterns which take account of miscarriage of plans, gross errors, defensive kills, and statistical variation in the accomplishment of objectives.

Finally, computer programs have been written to make it possible to put all of this diverse information together and, in effect, to run hypothetical attacks against the United States. The computer programs cover computation of casualties, the losses of other resources, and the preparation of summaries of what is left for recovery.

Computer summaries prepared by the National Damage Assessment Center have thus far been presented primarily in tabular form; however, techniques have been developed for mapping what might be called the "attack environment." Maps showing weapons effects, particularly fall-out, at a standard scale of 1:2,500,000 are used extensively. Larger scale maps at 1:500,000 will soon be used for the portrayal of weapons effects in greater detail in metropolitan areas. All such maps are printed routinely on a standard high-speed printer. Plans are well advanced for computing bar and line charts, based upon data contained in the damage summary tables.

All of the above information—tables, maps, and charts—will be stored on a high-capacity drum system now nearing completion. Any particular portion of the stored information can be called up, in a matter of seconds, for display on the face of a number of large cathode ray tubes. The information in the drum system is kept up to date by a Univac Scientific Computer which serves as the principal analytical tool of the Center.

In the event of an actual attack, all of the analytical procedures mentioned above (except the theoretical gaming of a hypothetical attack) would be utilized to provide initial estimates of the status of surviving United States resources. A rather extensive data-transmission network, including equipment ranging from ordinary teletype to 300-character-per-sec equipment, will permit dissemination of damage estimates to government relocation sites and regional centers. Later information from such sources as aerial surveys, statistical samples, and field censuses and reports will be used to update the early computer estimates of the condition of resources. The updated information will be summarized, mapped, charted, stored, displayed, and disseminated in the same manner as the initial computer estimates.

In the earliest days of the National Damage Assessment Program it became apparent that adequate preparation for nuclear attack against the United States would require more than intuitive judgments based upon analysis of a number of hypothetical attacks. What was really required was a mapping of the new hazards in much the same way that temperatures and rainfall contour maps are prepared for agricultural purposes. The principal difference was that these maps needed to be prepared *before it "rained" the first time.* Furthermore, the mapping needed to be done for different families of attack patterns and for different time periods.

Initial estimates of the time required to "Monte Carlo" a single attack, using about 100 trials, ran from six months to one year. Improved formulation and a more modest type of fallout model reduced the time to a few weeks. Further improvements in formulation, now in process, will reduce the computation time to a few days, even though a much greater amount of information will be produced.

The final results come out in two forms: 1) probability tables, showing the two-way frequency distribution of blast and fallout hazards, and 2) maps, with sufficient printed code numbers to permit the drawing of hazard (blast and fallout) contours. Such tables and maps quantify the risks and provide a basis for rational steps to reduce or minimize risks in an economic manner.* Analysis of several families of possible attack patterns can reveal the common denominator of probable hazards at points throughout the United States.

The results of such analyses are generally classified. However, certain important results have been released in unclassified form. The use of such studies by OCDM has led to some important recommendations for the protection of life and property in the United States. One such recommendation is that each family should now construct a suitable fallout shelter, stocked with at least a two-week supply of water, food, and other essential items.

**The computer program for this computation is appropriately named RISK.*

# transducers: key to sonar

**effective detection of submerged objects, a vital consideration in submarine weapons systems design, hinges upon proper use of translation devices for the conversion of acoustic and electrical energy**

**By George Rand***
**and**
**John Devine†**

Acoustic compressional waves in the sonic and ultrasonic ranges represent the most effective means of determining the range, bearing, and depth of submerged submarines

Because of this, electronic engineers are concentrating in many defense projects on the problem of developing improved sonar systems. Sonar, a word coined from *SOund Navigation And Ranging,* generally applies to the various types of underwater sound devices for the detection of submerged objects. The devices are also useful in oceanographic work.

The key element of a sonar system is that instrument which translates the acoustic pressure fluctuations into electrical signals: the electroacoustic transducer. This unit affects both the transmitted acoustic energy level as well as the electrical signals received by the sonar. The transducer, too, is a controlling factor in the system's directional characteristics and its receiving signal-to-noise ratio.

In the parlance of the sonar engineer, the term, *transducer,* refers to a reversible device useful for both reception and transmission. A unit designed specifically for reception is known as a *hydrophone,* while its counterpart for transmission is a *projector.*

Sonars vary in complexity and scope. Their operational principles may be classified in two fundamental types. These are the *passive,* or listening, sonar, and the *active,* or echo-ranging, sonar.

**Engineering section head, Surface Armament Division, Sperry Gyroscope Co. Division of Sperry-Rand Corp., Great Neck, L. I., N. Y.*

*†Engineer, Surface Armament Division, Sperry Gyroscope Co. Division of Sperry-Rand Corp., Great Neck, L. I., N. Y.*

The former is used to search for underwater noise-producing objects and can give target bearing at great ranges while remaining silent in itself. Active sonar is similar in operation to a radar system. Pulses of sound energy are transmitted into the water by the sonar transducer, and upon striking a submerged object, part of the sound energy is reflected back to the transducer.

In a passive sonar system the underwater sound is detected by hydrophones which are acoustically sensitive. When compressional sound pressures reach it, the hydrophone generates small voltages which are amplified and used to indicate the presence of the underwater sound source to the operator.

Active sonar makes use of an echo which indicates the presence of a submerged object. The time interval between the transmission and reception of energy serves as a measure of the range. Echo-ranging sonars have the advantage over conventional listening sonars of providing range information as well as bearing data. They have, however, the disadvantage of much shorter range.

A sonar transducer consists of several active elements. The latter may be either magnetostrictive, piezoelectric, or electrostrictive types. At the lower frequencies, some use is made of electro-dynamic transducers similar in construction to that of loudspeakers. The active elements are housed in metal or plastic with a rubber cover, or boot, isolating the elements from the water. Passive electrical matching elements complete the device.

Transducers may be classified also in respect to their radiating surfaces. These are plane-faced piston, multi-element cylindrical, and straight-line; known, respectively, as searchlight, scanning, and line transducers (or hydrophones).

A depth-sounding, circular searchlight sonar transducer weighs about 100 pounds. It incorporates a crystal array having an active diameter of nine in. The complete assembly has an over-all housing diameter of 16 in. and a height of about 10 in. The steel housing contains two watertight compartments, the crystal array being mounted in one chamber which is covered by an acoustically transparent rubber boot.

The crystal plates, each 2½ in. long, 1¼ in. wide, and ¼-in. thick, are isolated by a rubber cork pressure-release material. The array is mounted on a metallic plate, referred to as the backing plate, in order to achieve a transducer resonant frequency lower than that obtainable with the basic crystals alone. An inductor tunes out the capacitive reactance of the crystals and presents a pure resistive load to the transmitter at the operating frequency.

A scanning transducer consists of a cylindrical housing on which are mounted 24, 48, or more identical staves, each containing a number of active elements. The stave compartment is oil filled or separated by an oil layer from the rubber boot that is stretched around the housing. The central compartment of the transducer contains impedance-matching elements, usually one for each stave, and necessary cable entry and sealing holes. A bottom cover seals the central compartment from the sea water.

A typical crystal transducer of this type consists of 48 staves, has a diameter of 19 in., an over-all height of 26½ in., and weighs approximately 600 pounds.

A line-type hydrophone consists of three 1½-in. diameter 1½-in. high barium titanate ceramic cylinders, corprene separators, and a rubber coating to insulate the cylinders from the water. Since the basic radial resonance of these cylinders occurs near 40 kc, the low-frequency response of the hydrophone is relatively flat with frequency. Larger size ceramic cylinders operating in the radial, or circumferential, resonant mode can also be used as sonar projectors to produce an omnidirectional directivity pattern in the plane of the diameter. The pattern is a plane containing the long axis of the projector as a function of its height.

The pertinent characteristics of a transducer, such as resonant frequency, efficiency, voltage response, directivity pattern, power-handling capacity, and impedance, are controlled to a large measure by the type, shape, size, and mounting of the transducer active elements. The half-wavelength longitudinal (length equals a half-wavelength in the material) and the one-wavelength thin-walled cylinder (circumference equals a wavelength in the material) are the basic types of elements used in sonar transducers.

Magnetostriction, associated with ferromagnetic metals, iron, nickel, and cobalt, and alloys of these metals, refers to the change in dimensions of these materials when placed in a magnetic field. It also applies to the inverse effect of change in magnetization when the dimensions are changed by an external force. The direct magnetostrictive phenomenon is known as the Joule effect. The inverse magnetostrictive effect is referred to as the Villari effect.

A magnetostrictive element consists of a laminated core structure or toroidally wound cylinder with a magnetizing element and electrical winding. A magnetic bias is required in order to prevent contraction on both positive and negative cycles of the sine wave and vibration at twice the applied frequency.

A magnetostrictive nonresonant radial-mode hydrophone element used with submarine sonar equipment consists of a nickel alloy tube fitted with a bar magnet to produce a permanent magnetic field in a toroidal electrical winding. The hydrophone has a diameter of two in. and a length of about three ft and is mounted horizontally topside on a submarine. When sound energy strikes the hydrophone, the strain causes a change in magnetization which induces a voltage in the winding. The acoustic energy is thus converted into electrical signals and these, in turn, are amplified to indicate the presence of a target.

Another transducer, used in sonar communications equipment, is a cylindrical resonant magnetostrictive transducer. It consists of a toroidal coil wound on a core of two identical Permendur scrolls which operate at remanence (the residual magnetization of a ferromagnetic substance subjected to a hysteresis cycle when the magnetizing force is reduced to zero) and have a nominal resonant frequency of 8.5 kc. The scrolls expand and contract diametrically at the exciting frequency.

An interesting magnetostrictive element for sonar application is the mass-loaded ring vibrator, shown below. The fundamental resonant frequency of a ring vibrator is proportional to the ratio of the stiffness to the mass and, therefore, to its average diameter. Increasing the radial thickness of the ring increases its mass but also increases its stiffness in approximately the same ratio so that its fundamental radial frequency changes very little.

Because of this, rings which are resonant in the lower portion of the audio frequency range are very large in diameter. A structure of a given size can be made to resonate at a much lower frequency than the fundamental resonance of an equivalent ring by increasing the mass of

the ring and decreasing its effective stiffness.

Magnetostrictive transducers have certain basic limitations which include the magnetostrictive effect of the core material, the strain level that can be tolerated, the dissipation of heat generated in the core, and the geometry of the elements. These place a limit on performance and operational characteristics.

The efficiency of these transducers may be as high as 80 per cent at low levels but usually falls considerably below 40 per cent under high-power conditions. They are characterized by rugged construction, relatively high weight, high Q, low driving impedance, and narrow bandwidth. The Q of an unloaded transducer may be several hundred. However, when the transducer is water loaded, the Q will vary usually between 5 and 40, with the usual value falling in the region of 10 to 15.

Piezoelectric effects were first demonstrated by Jacques and Pierre Curie after they had discovered that certain crystals became electrically polarized when compressed in a particular direction. Little advancement was made from 1880 until World War I when the submarine menace resulted in the first quartz electro-acoustic transducer.

Following World War I, the piezoelectric field was relatively neglected until the early 1930's when interest was renewed in the commercial application of piezoelectric crystals such as Rochelle salt (sodium potassium tartrate). Interest mounted rapidly. Several hundred natural and synthetic crystals were found to have piezoelectric properties. A major contribution to the transducer art during World War II was the growing of ammonium dihydrogen phosphate (ADP) crystals, widely used in sonar transducer construction.

Only Rochelle salt, lithium sulfate, and ammonium dihydrogen phosphate are used to any extent in sonar work. The application of Rochelle salt is very limited because of its water solubility and wide variation of electrical characteristics with temperature. Rochelle salt has a piezoelectric activity about a thousand times that of quartz, but unfortunately this activity dwindles rapidly at temperatures above 45 degrees C and the crystal disintegrates above 55 degrees C. Lithium sulfate is used in thickness and volume-expander plates. It is particularly well suited for use in wide-frequency and omnidirectional hydrophones.

The majority of crystal sonar transducers, particularly units for high-power operation, use ADP elements. These crystals provide high electro-mechanical coupling. In addition, they are linear, reversible, extremely stable with temperature and exhibit no hysteresis effects. ADP crystals are stable up to 100 degrees C and do not dehydrate since they contain no water of crystallization. At normal operating temperatures, ADP crystals have a higher electromechanical coupling coefficient than any other available nonferroelectric crystal.

ADP crystals are grown in large quantities in supersaturated solutions. Usually, the bars grow to a size of from 12 to 16 in. in length and approximately four in. square before 45 degree z-cut oriented plates are cut from them for transducer application. The z-cut is one made perpendicular to the bar's longitudinal (z) axis, and 45 degrees to the plane (x-y) axis.

A sonar transducer is made up of a large number of these ADP crystals cemented into an array. The array is bonded to a metallic backing plate or to a pressure release material, the entire assembly being mounted into the housing with proper acoustic isolation.

"Electrostriction" is defined as the deformation of a dielectric when subjected to an electric field. It occurs as a low-magnitude effect in all materials. In some, however, such as barium titanate (a ceramic material which has gained wide popularity because it is amenable to common ceramic techniques and capable of being shaped into complex forms), large electrostrictive effects are observed when its molecular dipoles are oriented by means of a polarizing voltage. When stressed, barium titanate behaves as though it were piezoelectric and develops potential differences.

Barium titanate ceramic has a high dielectric constant which varies with temperature and peaks sharply at the transition point. This, as well as its other characteristics, can be altered, however, with the addition of certain additives. Chief among these are lead and calcium titanate.

The transition temperatures of straight barium titanate occur at around 10 degrees C and 120 degrees C and this material, therefore, should be operated below 95 degrees C since loss of activity occurs if the upper transition is exceeded. Additives can reduce the lower Curie temperature to —15 degrees C or suppress it almost entirely, or raise the upper transition temperature to approximately 150 degrees C. This gives the designer a wider choice of operating temperature ranges than that available with most transducer materials.

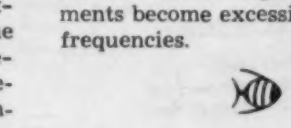
The addition of calcium or lead will usually satisfy the capacitance-temperature variation requirement for hydrophones. A combination of calcium, lead, and other additives can be used for increasing the coercive force by as much as 300 per cent. This allows greater power inputs to the ceramic without saturation or depolarization. These additives, however, also result in lowering the piezoelectric activity and a reduction in the dielectric constant and electromechanical coupling coefficient.

Newer materials have been introduced recently which tend to increase the operating temperature range of the titanates. Two of these newer materials, lead zirconate-lead titanate (PZT) and lead metaniobate, show Curie points of 380 degrees C and 575 degrees C. Such characteristics permit high temperature operation without deterioration. Both have lower dielectric constants, about 800 for PZT and 280 for the lead metaniobate. Both of these compositions exhibit about twice the efficiency of barium titanate as far as voltage generation is concerned.

The principal advantage of barium titanate for sonar transducer use is its high dielectric constant and resultant relatively low impedance. It is resistant to moisture, rugged, relatively inexpensive per unit of area, and is capable of operating through a wide temperature range. The fact that it can be produced in a great variety of sizes and shapes is also useful.

The choice of the specific active material to use in a transducer is based upon numerous factors. No specific rules can be given. In general, however, barium titanate is usually found most suitable for application involving frequencies above 100 kc. In the 10-to-100 kc range, all three groups of materials can be used for efficient operation. Below 10 kc, barium titanate is again a convenient material to use.

Eddy current losses, which increase as the square of the frequency, tend to limit the operation of magnetostrictive elements at the upper frequencies. On the other hand, the size and weight of these elements become excessive at the lower frequencies.



Underwater Engineering News

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January 14, 1960

Published by Sheffield Publishing Co. — 644 Washington Building, Washington 5, D. C. — District 7-8570

Erik Bergaust, President and Publisher

## NAVY ASW SPENDING FOR 1960 TABULATED

Before FY 1960 is over, the Navy will spe
on anti-submarine warfare equipment and acti
About $500 million of this money will go for
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## BILLION DOLLAR FRAM PROGRAM MAY BE Post

More money to ...
and ...

Underwater Engineering News

January 21, 1960

District 7-8570

Underwater Engineering News

Vol. 2, No. 9

March 8, 1960

Published by Sheffield Publishing Co. — 644 Washington Building, Washington 5, D. C. — District 7-8570

Erik Bergaust, President and Publisher

## SERIES OF RECORD-

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## SOVIETS PUSH NUCLEAR SUBMARINE PROGRAM

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Underwater Engineering News

Vol. 2, No. 14

June 15, 1960

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Erik Bergaust, President and Publisher

## MAGNUSON SPEAKS OUT IN UNDERWATER ENGINEERING MAGAZINE

Russia has "the largest number of profes...
Senator Warren Magnuson (D., ...
Research Act, says in an inte...
Magazine, which will be publi...
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world. Her research fleet is ...
have been the most extensive in...
Sen. Magnuson's bill (S. 2692 ...
for scientific research in the ...
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said.
There is no chance of Congress ...
been reported out favorably by S...
Commerce. Committee action has ...
adjournment rush will preclude an...
in 1961.

Underwater Engineering News

Vol. 2, No. 16

August 13, 1960

Published by Sheffield Publishing Co. — 644 Washington Building, Washington 5, D. C. — District 7-8570

Erik Bergaust, President and Publisher

## $400 MILLION FOR ASW, POLARIS R&D

The U.S. Senate is expected to d...
June 16. Among other things, the b...
provides $222 million for ASW resea...
provides even more -- a total of $2...
Funds are for fiscal year beginning ...
House conference.

## OCEANOGRAPHY CONFERENCE TO BE HELD

First international conference on o...
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increasing funds for international coo...
laboratory work.
U.S. delegation will consist of repr...
epartments plus the Coast and Geodetic...
A second meeting will be held in Hels...
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## IRA KAMEN TAKES OVER AT PORTLAND INDUSTRIES

Ira Kamen, former vice president of General Bronze Corp., recently took over the president's chair at Portland Industries Corp., South Portland, Me. In an interview with Underwater Engineering News, Mr. Kamen stated that he plans to convert the Portland firm, which has some 500 machine tools and better than one half million sq. ft. of manufacturing space, into an advanced scientific center for development and production of electronic and electro-mechanical systems. Immediate attention will be focused on the fields of space technology, anti-submarine warfare detection and warning equipment, and nuclear devices. Mr. Kamen has behind him a Board of Advisors including such names as: Sir Robert Watson Watts, father of Radar; Dr. John Teeter, Head Technical Aide to Vannevar Bush in the Office of Scientific Research and Development; J. R. Poppele, former Director of the Voice of America and President of the Television Broadcasters Association; and Dr. Elliot, President of the University of Maine.

* * *

## CONVERSION OF 2 ASW CARRIERS DELAYED

Department of Defense announced that a third attack carrier would be assigned to the U.S. Sixth Fleet. This move resulted from recommendations from the Joint Chiefs of Staff. With this move the carrier strength of the Sixth Fleet and the Seventh Fleet will be maintained for the ...imum of three attack carriers each deployed to the Mediterranean and Western

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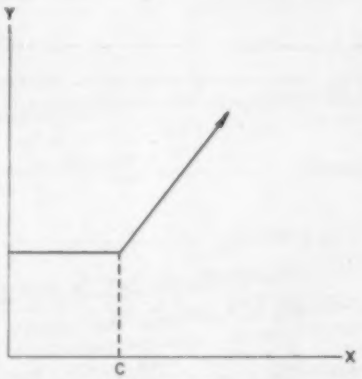
# torpedoes and underwater rockets:

## Here's a Close Look At Tomorrow's Weapons -AND SOME BASIC CONSIDERATIONS

By Barron Kemp

Almost all activities with torpedoes in the United States during recent years have been in the modification or improvement of existing systems with a minimum of change. As a matter of fact, our most modern torpedoes today very closely resemble the original prototype designed by Robert Whitehead 90 years ago. Were it not for our knowledge of the exceptionally superior performance of sea animals as stimulus, we might accept the Whitehead concept of torpedoes as the ultimate in basic design.

The concept of applying the principles of sea-animal locomotion to torpedoes is disconcerting to many people. Application of these principles seems to imply that torpedoes would resemble fish. Fish require special handling to maintain their viability; their bony and muscular structure is complex; they are elusive, wiggly, unreliable and slimy. On the other hand, the modern torpedo is an esthetically beautiful piece of machinery. It represents many years of expensive refinement of the Whitehead prototype and a tremendous investment of knowledge. It is powerful, rugged, reliable, smooth and shiny.




X IS A FUNCTION OF SPEED, REYNOLDS NUMBER OR RECIPROCAL CAVITATION NUMBER

Y IS A FUNCTION OF NOISE, BOUNDARY LAYER TURBULENCE OR DRAG

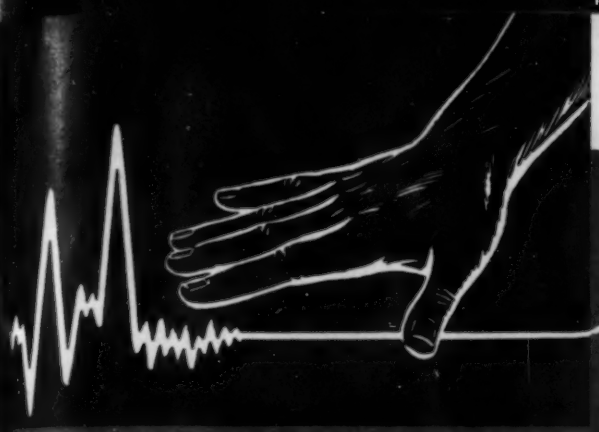
C IS THE CRITICAL VALUE OF X WHICH VARIES WIDELY WITH PROPULSION SYSTEM TYPE

**Fig. 1. Relationship between speed and noise of torpedoes.**

The objective of a torpedo is to deliver a lethal payload to a surface or undersea target. In contrast to weapons such as bombs and depth charges, mines and gun-fired projectiles, the torpedo is unique. It travels through water, is self-propelled and usually guided or homes on the target by means of self-contained equipment. Its only true counterpart is the air-to-air homing missile such as the FALCON and SIDEWINDER. During its history the torpedo has accounted for more enemy tonnage than any other weapon, and will probably be the weapon of the envisioned undersea submarine-to-submarine duel of the future.

Consideration of size and speed helps establish the boundaries of sea-animal locomotion for torpedoes. Both of these factors are closely related to range, accuracy, and stealth.

A torpedo must be large enough



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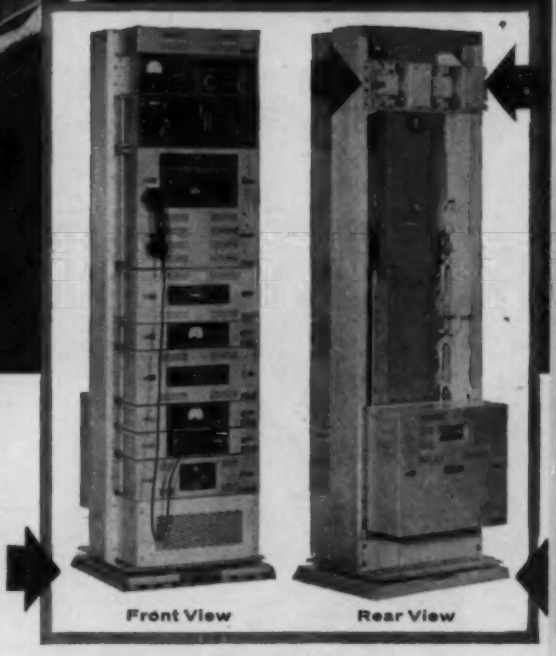


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**Table 1. FAST SEA ANIMALS REPORTED SPEEDS**

| Animal | Speed (knots) |
|---|---|
| Sail Fish | 70 |
| Sword Fish | 50 |
| Flying Fish | 35 |
| Porpoise | 32 |
| Mackerel | 26 |
| Barracuda | 24 |
| Whale | 21 |
| Salmon | 11 |

to carry its lethal payload and the auxiliary equipment necessary to get that payload to the target. This size is presently established at a diameter of 10 to 24 in., a length of seven to 24 ft, and a weight of 250 to 4,000 pounds.

It is conceivable that a slow, unguided torpedo can kill a much faster target if the target does not make evasive maneuvers. However, if part of the torpedo run involves pursuit, it is essential that the speed of the torpedo exceed that of the target. Five knots is generally considered a sufficient speed advantage so that as long as the maximum speed remains between 30 and 35 knots, a maximum torpedo speed of 40 knots should suffice.

With present acoustic homing torpedos, "rush" or "flow" noise around the nose begins to present a problem about 35 knots. However, self-noise from a propeller propulsion system creates problems at much slower speeds. Torpedoes have frequently been observed "chasing their own tails" as a direct consequence of self-noise generated by the propulsion system. This problem is solved to some extent in modern acoustic torpedoes by having more than one running speed — the speed being adjusted to the self-noise versus target-noise ratio. However, propulsion noise represents a serious problem that limits the speed of conventional torpedoes. The typical relationship between speed and noise is illustrated in Figure 1.

It is not yet established that the fastest fishes swim silently at high speeds, though submerged whales do. Nor is it certain that all of the fast sea animals employ passive and active sonar, although a few definitely do. Listening is limited in conventional acoustic torpedoes to a top speed of 30 knots because of self-noise. It is interesting to compare this with the maximum reported speeds of several sea animals listed in Table 1.

For sea animals traveling at speeds greater than 30 knots, there is no adequate evidence that their locomotion is either quiet or noisy. We

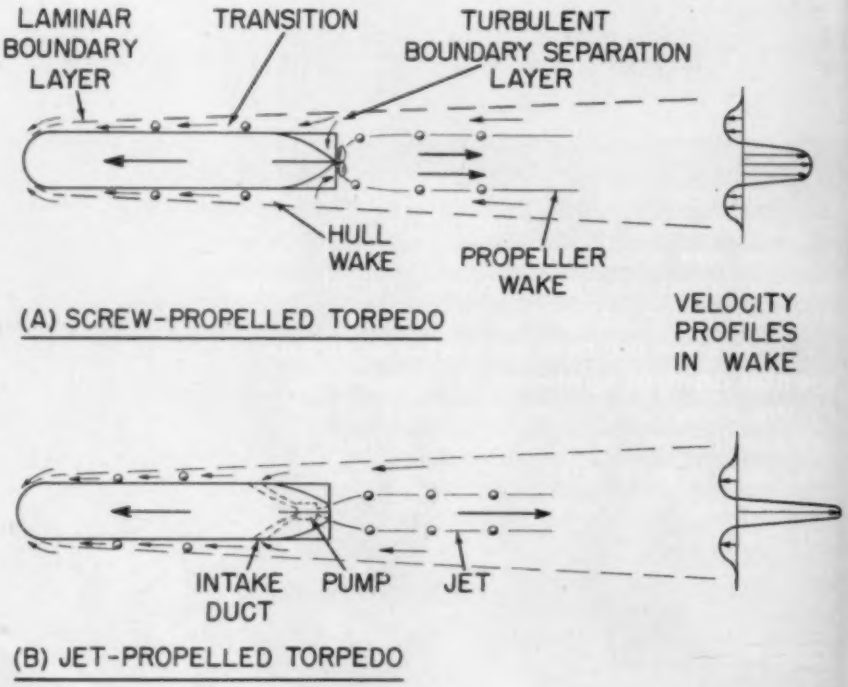



**Fig. 2. Energy wake (turbulence) is a result of counter movements of hull wake and propeller wake.**

**Table 2. PARTIAL HISTORICAL SUMMARY OF OSCILLATING AND UNDULATING PROPULSION SYSTEMS AND DRAG REDUCTION BY BOUNDARY LAYER CONTROL**

| Date | Originator | Nationality | Description | Outcome |
|---|---|---|---|---|
| 1848 | R. Fowles | English | Multiple oscillating tail fins | Patented |
| 1862 | W. H. Johnson | American | Multiple flexible oscillating tail fins | Patented |
| | H. Schramm | German | Single flexible oscillating-tail-fin boat driven by engine | Constructed |
| 1926 | C. M. Breder | American | Single rigid-tail boat driven by clock motor (ostraciform movement) | Constructed |
| | | | Undulating full-length-fin boat driven by clock motor (anguilliform movement) | Constructed |
| 1929 | M. Curry | American | Single flexible-tail-fin boat driven by leg power | Constructed and used in Burma during WW II |
| 1933 | G. Garland | American | Segmented body undulation driven by rubber bands | Manufactured as a toy. Navy project started—later dropped |
| 1956 | Wm. C. Shaw | American | Flexible annular bands around rigid hull pneumatically or hydraulically expanded and contracted in sequence to generate traveling wave | Patent applied for |
| 1957 | H. P. Williams | American | Single flexible tail in underwater vehicle driven by electric motor | Work presently in progress |
| 1957 | G. H. Bowlus | American | Undulating barrel surrounding rigid hull | Current work on undulating plate |
| 1958 | T. G. Lang & J. D. Brooks | American | Boundary-layer control by suction | Proposed, work currently in progress |
| 1958 | C. E. Weinland | American | Single flexible fin driven by swimmer, treading action | Proposed |

can be sure, however, that sea animals are at least quieter than our present torpedoes at the higher speeds.

**Shape** — The ideal torpedo shape for minimum drag seems to taper with increasing diameter, having a maximum at 50 to 75 per cent of the distance aft. In the case of sea animals, however, it appears that the ideal shape reaches its maximum diameter within the first 25 per cent, regardless of whether the animal has a sharp beak or blunt nose. This streamlined shape contributes to sea-animal locomotion, but is by no means the principal secret.

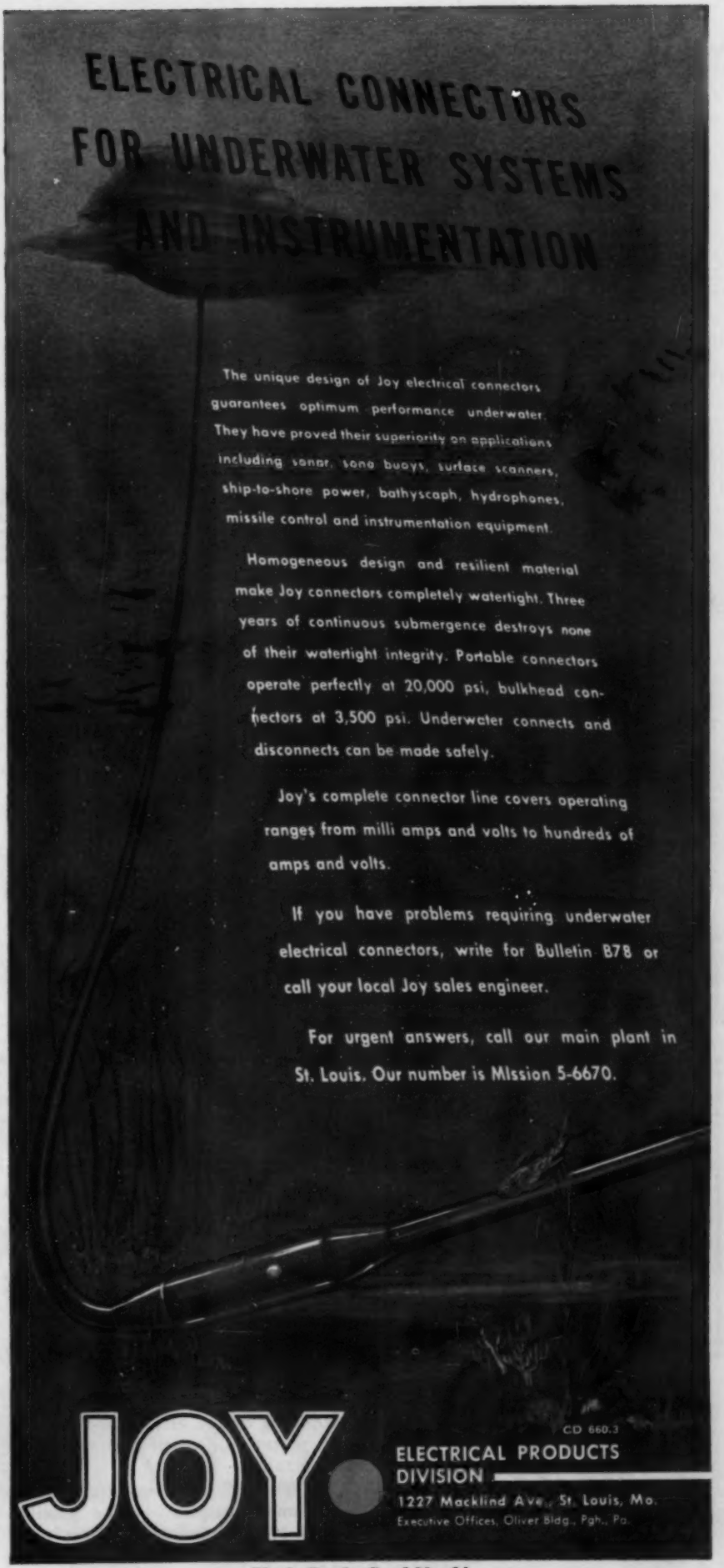
**Range** — Torpedo range must be great enough to provide safe standoff. Range is related to size and speed. With a homing or guided torpedo there is some dependence of accuracy upon range. The relation of range to stealth is dependent upon the noise and detectability characteristic of the firing vessel.

It is desirable to employ short ranges only in a few circumstances — surprise attack by the enemy and unexpected encounter with an unaltered enemy target. Lower limits of range are dictated by arming distance, proximity to the eventual explosion, and possibility of being attacked by the enemy after firing at him. Longer ranges are requisite with the advent of nuclear warheads. The desirability of added stealth also has intensified the quest for extension of the upper limit of range. This upper limit is presently 20,000 yards, although there are advocates of double this figure.

The range of existing torpedoes only approaches the desired values. The range of sea animals is, of course, unlimited although they have the advantage that they can stop, rest and feed. Only the range that sea animals can achieve at a specified sustained average speed is of interest. It is here that sea animals demonstrate remarkable superiority over torpedoes.

If torpedoes were available that performed as well as salmon, we could have the ideal torpedo weighing 450 pounds, traveling 20,000 yards at 45 knots — and remaining silent.

**Accuracy** — More gains have been made in the field of accuracy and more innovations put into effect than in any other branch of torpedo technology. With the introduction of acoustic homing, however, we are now confronted with problems resulting from failure to progress in the field of propulsion. In-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deed, we can afford to sacrifice at least half the efficiency of the propulsion system if torpedoes operated more silently.

It is doubtful that this sacrifice would be necessary if a quiet propulsion system were developed. It is almost a universal rule that quiet machinery is more efficient than noisy machinery; yet it is interesting to observe that almost invariably the emphasis has been on increased efficiency or drag reduction of torpedoes rather than the quiet operations that can be achieved by sea animals. The silence of sea-animal locomotion unquestionably contributes to the ability of the porpoise to "see" and identify objects as much as two miles distant with the aid of its "sonar" eyes.

This sonar of the porpoise is capable of a high degree of discrimination. It can locate openings in nets and identify garbage scows at distances of two miles or more. It is questionable whether these feats could be achieved if the locomotion system of the porpoise were noisy.

Very interesting observations were made during World War II with reproductions of a captured German GNAT acoustic torpedo. During tests made off Key West, porpoises frequently pursued and frolicked around the torpedo, target and firing submarine. These animals clearly had no difficulty in achieving a feat that man was finding extremely frustrating. It is also quite clear that sea animals can outstrip torpedoes with respect to acquisition, identification and homing, which are the three requisites of an operational torpedo.

**Stealth** — About a year before the end of World War II, a group of German admirals and scientists met at Gotenhafen, their submarine research center. Until that time, Germany's submarine campaign against Allied shipping had been eminently successful. They had sunk more than 10 million tons, over 2,000 Allied ships — almost strangling the supply lines to England and Murmansk. But now the Germans had lost the advantage of stealth. The Allies were dodging and outfoxing the German torpedoes. They were detecting the presence of U-boats, chasing, depth charging, sinking and capturing them. Life was becoming very difficult for submariners.

Everyone attending the meeting agreed that all types of propulsion systems then in use were easily detectable because of too much noise and wake. The question of "oscillating fin" propulsion for torpedoes — simulating sea-animal locomotion — was discussed, with agreement that this work should be expanded except for the pressures of too many other tasks.

The principles of sea-animal locomotion were used with success during World War II for surface craft. A boat propelled by a single fin tail was used by British Commandos in Burma. This was a reasonably fast propulsion mechanism which made no noise. A man could propel such a craft much longer than he could row or paddle, without excessive fatigue. This example shows that no price was paid for silence, but rather that silence brought a bonus of increased efficiency.

Stealth requires both silence and wakelessness. If both the submarine and torpedo have these attributes and the target does not, the submarine can approach without warning, attack without alerting, the torpedo can home on the target without chasing its tail, and the submarine can retreat without detection. It is also interesting to contemplate the situation where the target has these attributes of stealth and the submarine and torpedo do not.

The wake of a torpedo includes visible bubbles, particles of oil, and the energy deposited aft of the torpedo. This energy wake (turbulence) may last for hours. It is deposited by screw and jet propelled vehicles as a direct consequence of the counter movements of the hull wake and propeller wake (Figure 2).

Hull wake is a conical region aft of the vehicle which contains fluid moving with the vehicle. This results from drag or friction against the hull. Propeller wake, or race, is a conical region inside the hull wake that contains fluid moving aft with momentum neutralizing the forward momentum of the hull wake. Sea-animal locomotion appears to approach the "ideal" wakeless propulsion system which completely eliminates the hull wake, obviating the need for eliminating propeller wake.

Studies conducted in bioluminescent water show that the wake of propellers is brilliantly visible in contrast with the wake left by seals, which is barely visible, and that aft of porpoises, which is almost undetectable.

**Applications of Sea-animal Locomotion Principles** — The possibilities of applying the principles of sea-animal locomotion to torpedoes do not necessarily involve imitation. That is, the addition of scales to a torpedo would be no more improvement than the addition of feathers to an airplane; nor does it imply that a torpedo has to be "wiggly" in order to utilize sea-animal locomotion principles.

The locomotion principles employed by a fast fish and most swimming mammals provide one of the few examples where the performance of living creatures far surpasses that so far attained by man and his machines.

Careful sequential analysis of high-speed photos of fast-moving fish, eels, and porpoises show that most of these animals employ a motion described as anguilliform. This motion may be described as the generation of a traveling, almost

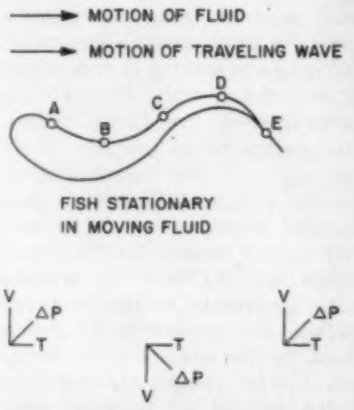
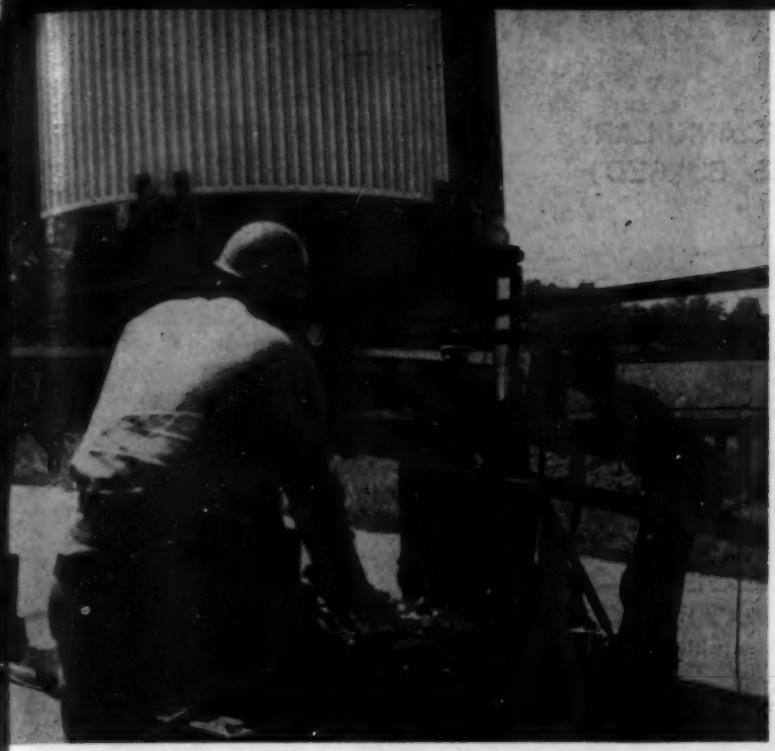



**Fig. 3. Forces exerted by anguilliform motion of sea animals.**

sinusoidal, wave, usually having increased amplitude aft. Such a motion involving lateral motions of the head and all parts of the body, as well as the tail, would exert forces either in the form of positive or negative pressure differentials as illustrated in Figure 3. Most of the surfaces of the body other than those having zero slope with respect to the axis of travel, as in "B" and "E" of the illustration, thus participate in the propulsive process.

The most significant factor in the fast, quiet locomotion of sea animals is "body participation," which creates a "propeller wake" in exactly the same location as the "hull wake," providing a propulsion system which actually "wipes away" the wake.

The stages of the swimming proc-



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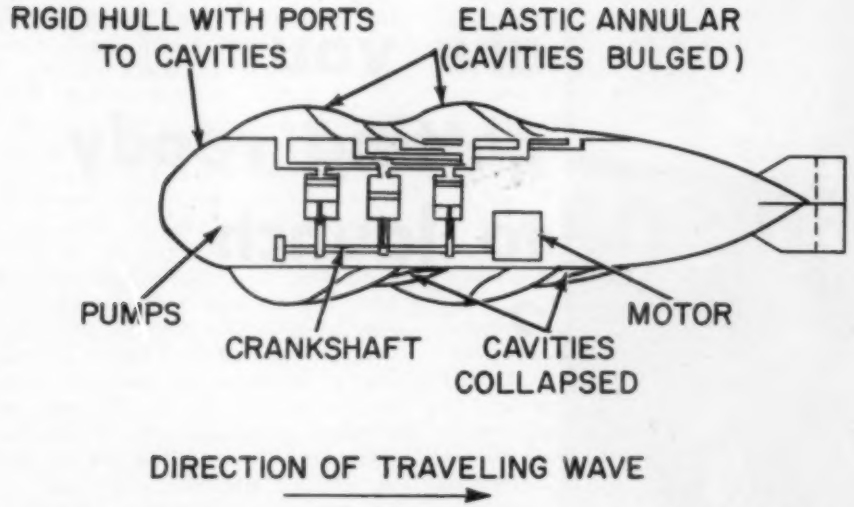


**Fig. 4. Three primary systems of underwater propulsion which have possibilities of application to torpedoes.**

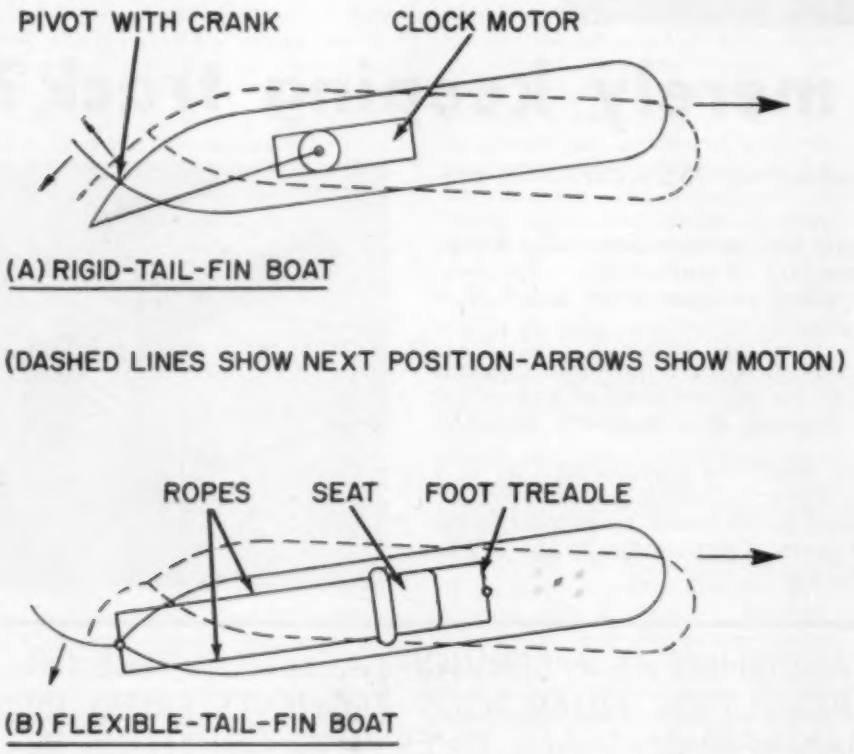


**Fig. 5. The body undulation system — quiet, efficient, and almost wakeless. Is it the ultimate in underwater propulsion?**

esses of a fast fish are as follows:

*Quiescent:* The fish remains stationary in space compensating for gill propulsion and overturning movements by means of fin undulation — principally with the spectoral and ventral (side) fins.

*Acceleration:* Quick darts or acceleration to cruising speed are achieved by violent undulation of the body (large amplitude) with head moving from side to side and extensive dorsal (back) and caudal (tail) movement.

*Cruise:* Moderate speeds are maintained with most fins folded close to the body and the body undulating in a carangform manner (single traveling sine wave).

*Maximum:* With motion approaching anguilliform (multiple traveling sine wave), the amplitude and wavelength are decreased but frequency is greatly increased. Most fins are completely folded.

Three primary systems of underwater propulsion which have possibilities for application to torpedo propulsion are illustrated in Figure 4.

The oscillating tail fin system is quiet, fairly efficient. It is a simple mechanical system that is fairly successful for use on boats and potential use by underwater swimmers. However, the detection, guidance and control equipment is subject to vibration. It is not fast and not wakeless.

A suction boundary-layer control system is more efficient than propellers alone. However, it is probably subject to clogging by plankton or sediment-filled water; has a speed reduction upon entering turbulent water, as in target wake; and has a fragile hull, noisy jet and propeller propulsion, and a turbulent energy wake.

The system offering the greatest possibilities is the body undulation type shown in Figure 5. This system, which is the ultimate in underwater propulsion, is quiet, efficient and almost wakeless. Although it faces possible design problems, these can be evolved by concentrating on the problems with maximum effort and application of facilities.

Table 2 brings out several feasible methods of achieving body undulation. One method has been successfully applied to a toy. The reluctance to try the others is usually excused by complaints of a lack of understanding of nonrigid-body hydrodynamic theory. However, this does not bother sea animals; they just keep going — fast and silent.

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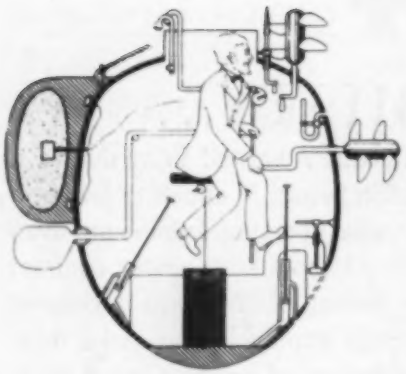
# the coming breakthrough in underwater propulsion

By Alfred J. Zaehringer

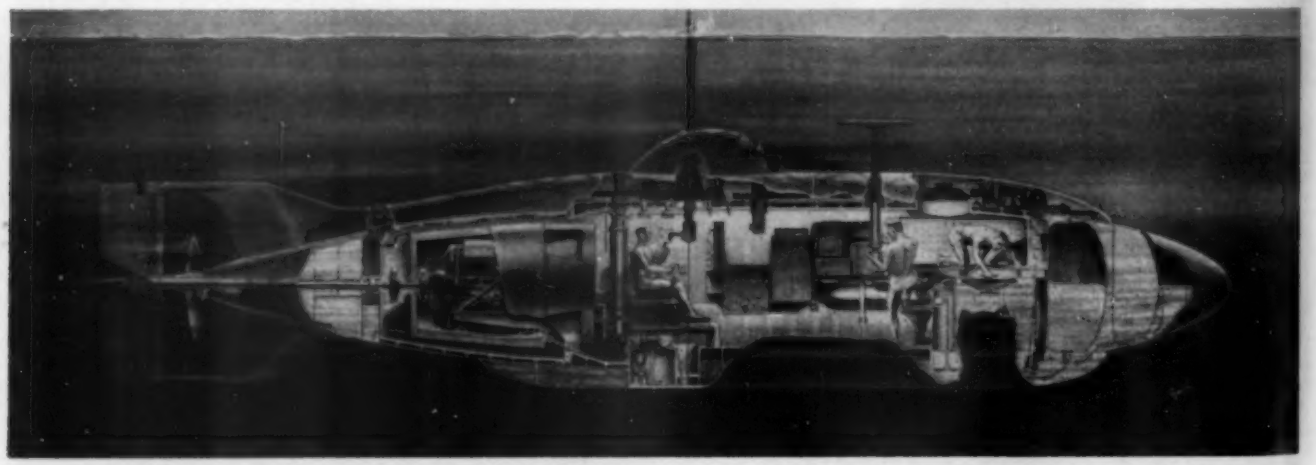


Bushnell's submarine,"Turtle"

Though the art of marine propulsion is quite old, it is relatively new in view of today's technology in other fields—notably the missile area. Underwater propulsion today is in about the state that the airplane was some 50 years ago. The trend toward higher speeds and longer ranges requires newer forms of energy conversion. These are available. But propulsion methods are few.

Aside from the paddlewheel (and its predecessor, the oar) there are remarkably few new and basically different methods of underwater propulsion. There are many ways of furnishing power, but actual propulsion mechanisms can be reduced to the screw propeller, hydrodynamic flow, and pure rocket thrust.

The submarine goes back at least to 1620, when the Dutch Cornelius van Drebell built a leather-hulled craft, powered by oars, which attained depths of 12 to 15 ft in the River Thames. The jet-propelled hydraulic pump was described by Togood Hays in 1661. David Bushnell is remembered for his submarine, "Turtle," which was built during the Revolutionary War. His sub was entirely hand-powered; screw props were used for both



The Fairchild X-1, four-man midget sub designed primarily for testing of harbor defenses, shown in cutaway view. Powered by diesel engine which uses fuel resulting from decomposition of hydrogen peroxide.

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This new system is one of a number of advanced ASW programs in production at Sperry's Surface Armament Division.

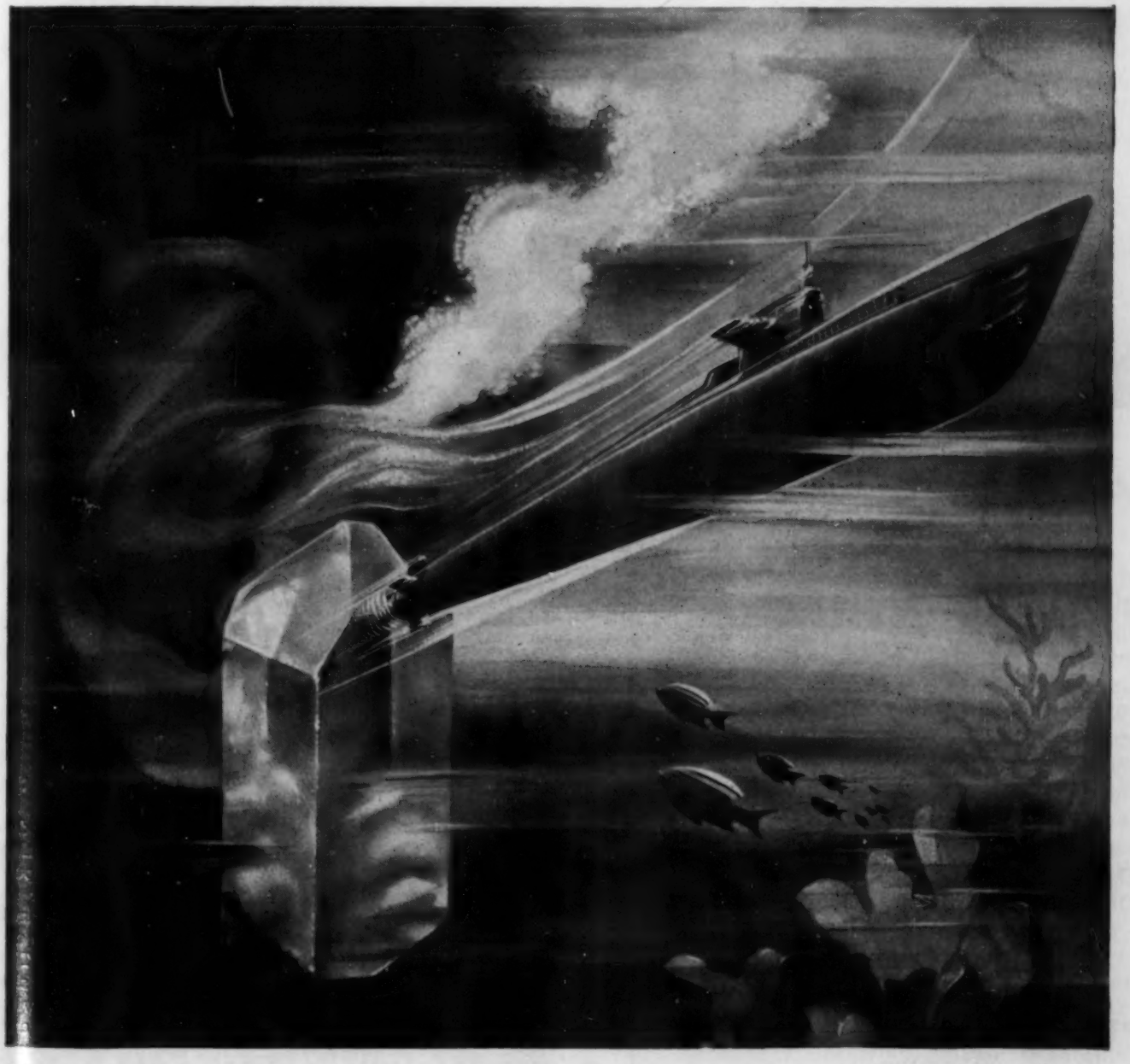

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**Table 1**
**Model Towing Tanks**

| Country & Location | Length (ft) | Width (ft) | Depth (ft) | Date |
|---|---|---|---|---|
| **USSR** | | | | |
| Leningrad | — | 21.7 | 9.2 | 1891 |
| St. Petersburg | 500 | 20.0 | 11.0 | 1893 |
| Moscow | 558 | — | 21.3 | 1933 |
| **USA** | | | | |
| Washington | 470 | 42.7 | 16.4 | 1898 |
| Ann Arbor | 360 | 22.0 | 10.0 | 1905 |
| Langley Field I | 2920 | 24.0 | 12.0 | 1931 |
| Langley Field II | 1880 | 18.0 | 6.0 | 1942 |
| Langley Field III | 360 | 24.0 | 8.0 | 1942 |
| Newport News | 56 | 8.0 | 4.0 | 1933 |
| Hoboken I | 109 | 9.0 | 4.5 | 1935 |
| Hoboken II | 75 | 75.0 | 4.5 | 1932 |
| Hoboken III | 313 | 12.0 | 6.0 | 1944 |
| Carderock I | 2775 | 51.0 | 22.0 | 1938 |
| Carderock II | 2968 | 21.0 | 10.0 | 1938 |
| Carderock III | 303 | 51.0 | 10.0 | 1938 |
| Carderock IV | 142 | 10.0 | 5.5 | 1938 |
| Evanston | 75 | 8.8 | 8.0 | — |
| Glen Cove | 93 | 10.0 | 5.0 | 1948 |
| Cambridge | 108 | 8.6 | 4.0 | 1951 |

forward propulsion and depth control. Robert Fulton's famous submarine, the "Nautilus", built in France in 1800, also used manually operated screw props. As early as 1899 cavitation, the present-day bugaboo of underwater propulsion, was recognized by J. C. Walker of Waco, Tex. Walker patented a method of pneumatic propulsion whereby air was emitted through tiny holes in hollow blades.

It was soon realized that undersurface propulsion (or for that matter, surface) could be advanced by the use of models in tanks. In 1874 Froude built the first model tow tank and came up with his Law of Comparison, which gave naval science its first taste of scale model techniques. Here in the United States, David W. Taylor did much work in scaling. A Navy test tank, located in Maryland near Washington, D. C., bears his name. Table 1 gives data on model tow tanks of the U.S.A. and those known to be operated by the USSR. Other nations have totals as follows: Austria, 1; Brazil, 1; Canada, 1; England, 7; France, 2; Germany, 7; Holland, 2; Italy, 3; Japan, 2; Spain, 1; and Sweden, 1. It probably can be stated that the number of model tow tanks bears a close relationship to a nation's naval prowess. It is believed, for example, that the Soviet Union has added some 10 to 12 model tanks since the end of World War II.

**The Screw Prop**—The prop can be turned by hand as in the case of Bushnell's and Fulton's subs. However, modern technology has given a wide variety of possible powerplants for turning the screw. Typical powerplants used for submarine, torpedo, and/or underwater missile screw propulsion include:

1) Batteries (torpedoes)
2) Diesel engine (subs)
3) Rocket/turbine (torpedoes, underwater missiles)
4) Nuclear powerplant (subs)
5) Fuel cells, (torpedoes, missiles, eventually subs)

By and large, the prop is still the most widely used of all underwater propulsion methods. However, screw propellers have been pushed to the very pinnacle of efficiency and it is not likely that significant gains can be made in the future. The prop is definitely subject to speed limitations, and also to shaft, seal, and bearing limitations. Basically, a prop design is good only for a particular speed and power. However, variable pitch props have allowed underwater speeds of 50 knots and over.

Screw props, especially for underwater use, have a tendency to roll. For this reason, torpedoes use contra-rotating props. All World War II torpedoes of the U.S. were in this category. Aerojet's "Mini-Sub" also uses contra-rotating screw props. However, the USS *Albacore* (AGSS 569), will not use contra-rotating props because other methods of roll stabilization are used.

During World War II, the Germans developed the Kriesloff Cycle Diesel for screw propulsion. Diesel exhaust normally contains unburned fuel and free oxygen. This exhaust gas was recycled to the diesel with the addition of air from an air bottle.

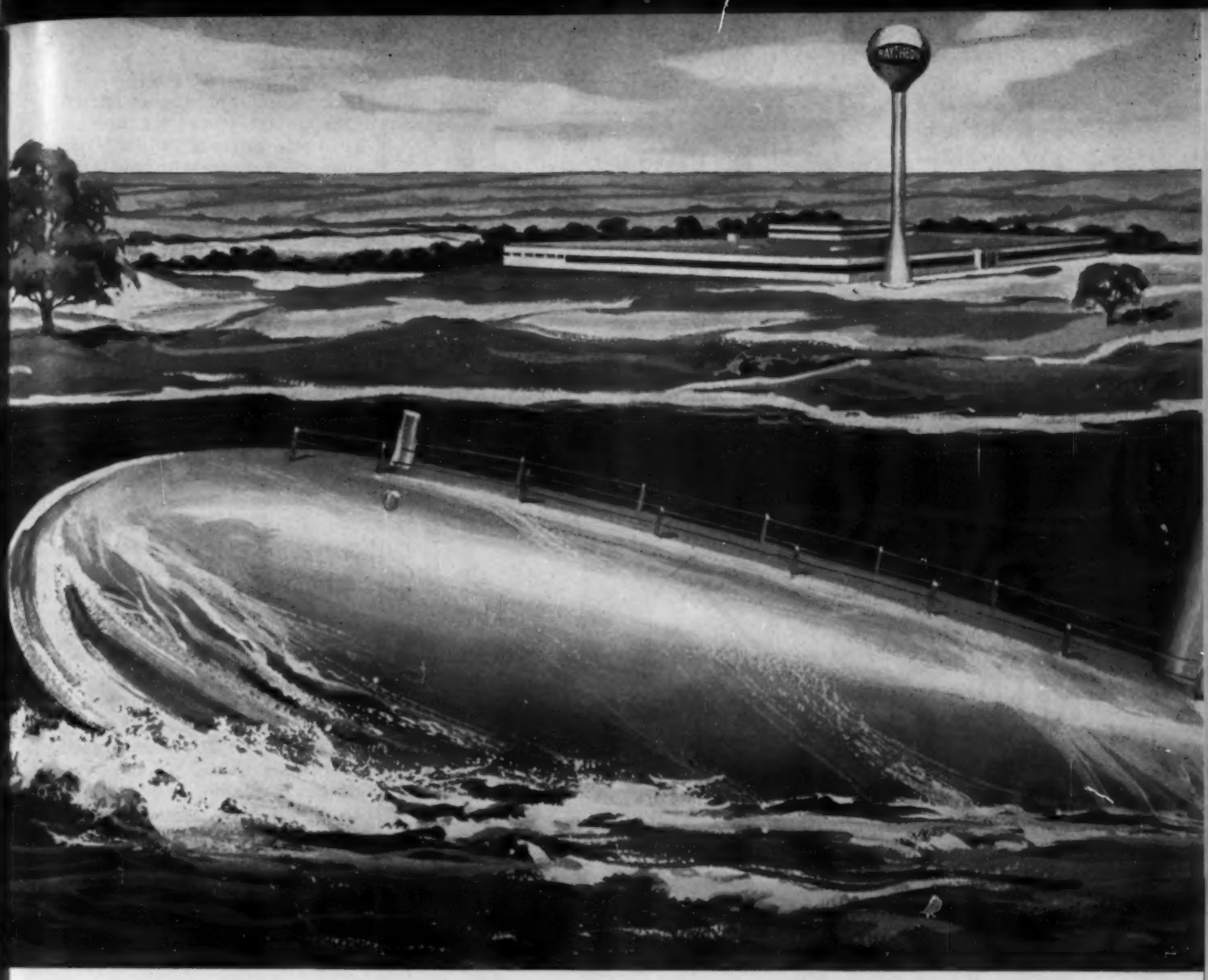
Another closed cycle developed by the Germans in World War II used hydrogen and oxygen, derived from the electrolysis of sea water, which were burned in diesel cylinders for submerged propulsion. Later, the U.S. used liquid oxygen in postwar tests, but development of the nuclear power plant led to abandonment.

A more famous closed cycle developed by Germany during World War II was the Walter Cycle. The decomposition of hydrogen peroxide to steam and oxygen by the use of a catalyst was used to drive a steam turbine. This technique was elaborated on by Fairchild after the war in its X-1 sub. Decomposition of hydrogen peroxide was used to provide power products for the running of a diesel engine.

**Hydrodynamic Flow** — Hydrodynamic flow is essentially an analog to the common type of jet propulsion used by aircraft. Water is sucked into a chamber, pressurized by a pump, and then allowed to accelerate through an exit nozzle. The result is a forward thrust, opposite to the jet flow, in accordance with Newton's Third Law of action and reaction. This hydraulic jet pump may be operated by a turbine, gear pump, or some other means. In

**Table 2**
**UNDERWATER PROPULSION PERFORMANCE**

| Method | Performance Parameter |
|---|---|
| Sea Watery Battery | 2.5 |
| Ethanol/Air/Water | 3.0 |
| Ethanol/90% Hydrogen Peroxide/Water | 15.5 |
| Ethanol/100% Hydrogen Peroxide/Sea Water | 28.5 |
| Fuel Oil/100% Hydrogen Peroxide/Sea Water | 30.0 |
| Ethylene Oxide | 11.5 |
| 100% Hydrogen Peroxide | 13.0 |
| n-Propyl Nitrate | 15.5 |
| Solid Propellant | 23.0 |
| Lithium Metal/Sea Water | 35.0 |
| Magnesium Metal/Sea Water | 65.0 |

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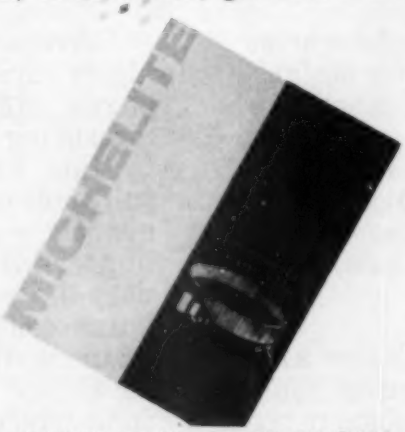


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1921, Morize of France described such a jet ejector for propulsion. This was followed in 1938 by Coanda of France with his jet umbrella. Combustion gases can also be used to induce jet flow. In 1946, McCollum of Chicago used gases from an internal combustion engine to induce jet flow in an annular flow chamber. Pump "jet boats" are becoming quite popular because of their high maneuverability, low draft, and absence of a dangerous rotating prop.

**Rocket Propulsion** — An obvious way of increasing performance is to utilize the rocket principle. Since weight is no great problem in water or underwater, the fact that the rocket has to carry all its propellants with it is no great problem in naval practices. Table 2 compares various rocket methods of propulsion with more conventional methods. The battery and air-fuel methods are used for torpedoes. Hydrogen peroxide and a fuel can be used for straight rocket thrust, to operate a turbine, or even to operate a diesel engine. The monopropellants —ethylene oxide, 100 per cent hydrogen peroxide, and n-propyl nitrate—all have poorer performance than the steam turbine or diesel methods. Solid propellants start to approach the efficiency of the combination methods. Typical underwater propulsion applications of solid propellants, to date, however, have been only for torpedo or small missile use. Because solid propellant operation is quite simple and highly reliable, it probably will be considered for larger-scale applications.

In 1944 Fritz Zwicky proposed using water and a reactive metal for underwater propulsion. The reaction of lithium metal or magnesium metal with water liberates generous quantities of heat. The reactions are hypergolic (self-initiating) and products are usually the metal hydroxide and hydrogen. These metal-water reactions take place as violently as, say, the combustion of the metal with air or oxygen.

**Other Power Sources** — Use of nuclear power for underwater propulsion is an accomplished fact. The fission process liberates heat, which is picked up by a heat transfer material. The hot fluid (or an auxiliary fluid such as water) is then used to operate a steam turbine. This gives subs an almost unlimited cruising range on a very small amount of fuel. The problems of shielding may limit practical sizes to very large craft. As an alternative, radio-isotopes might be

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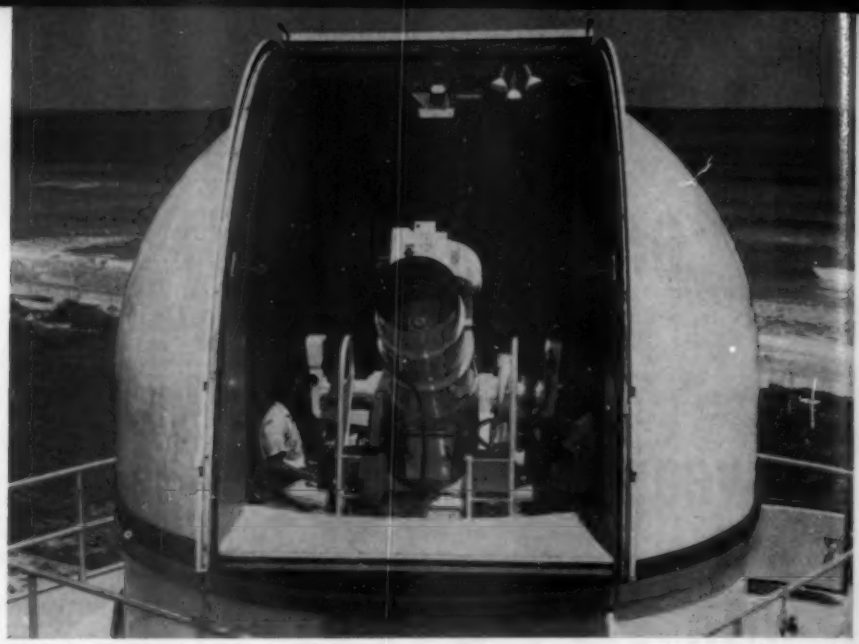

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used in electrically driven undersea missiles and eventually submarines.

The use of electrical power has always appeared attractive for underwater use. Prior to the advent of the nuclear reactor/steam turbine / electrical generator system (which consumes no oxygen and hence can operate submerged), electrical energy always had to be stored in batteries. World War I and II subs, for example, used the diesel-electric system in combination with batteries. At first the ordinary lead battery was used. Since then newer batteries have come along. Silver cells and the new magnesium/sea water/silver chloride combination have been tried. The fuel cell now promises to offer new possibilities first for underwater missiles and then even subs. The fuel cell is an electro-chemical system that allows fuel and oxidizer in a gaseous form to combine directly and to release electrons, e.g., an electrical current. One fuel cell allows gaseous hydrogen and gaseous oxygen to form water and electricity. One fuel cell, GE's ion-membrane unit, produces over 100 watt hours per pound; at 1.0 volts, the specific fuel consumption is about 0.08 pound of hydrogen per kw. GE has proposed a fuel cell system for a sub "smaller than existing nuclear submarines." The entire system would weigh some 148 tons and occupy a volume of 9,600 cu ft. The system is based on LOX and fuel oil. The company figures that in another five years of technology, the system weight could be dropped to 114 tons and a volume of 8,200 cu ft. In place of hydrogen or fuel oil, the system could operate on ammonia or possibly even the boron fuels. Thus, a quiet, nonradioactive, and heatless system could evolve for subs.

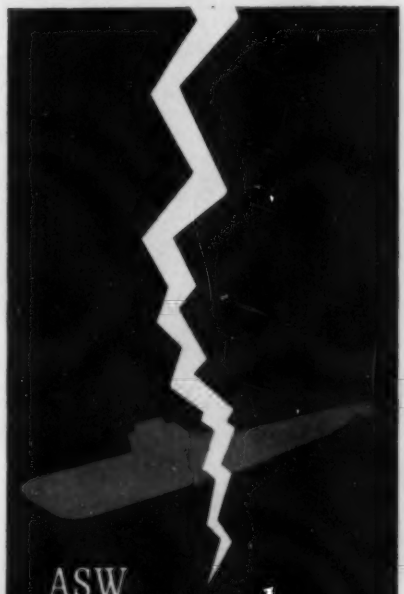
Activity in the fuel cell area includes:

1) Low - temperature, low - pressure, 50-100 degrees F, 1-50 psi (Hydrogen-oxygen or air-fuel). Standard Oil (NJ), National Carbon, General Electric, Electric Storage Battery, Allis - Chalmers, Ruhrchemie (Germany).
2) Medium-temperature, high pressure, 400-600 degrees F, 400-1,000 psi (Hydrogen-oxygen). United Aircraft, Leesona Corp., F. T. Bacon (England).
3) Low-temperature cells using hydrocarbons and oxygen or air. Allis-Chalmers, National Carbon, Standard Oil (NJ), Leesona Corp., Ruhr-chemie (Germany).
4) High - temperature, 400 - 1,000 degrees F cells for use with hydrocarbon fuels and air. Low pressure and fused salt electrolytes. Curtiss - Wright, General Electric, Pittsburgh Consolidation, United Aircraft, Leesona, Ketelaar (Holland), Sondes Places Research Institute (England).
5) Other fuel cell works include Chrysler, Dow Chemical, Gulf Oil, Koppers, Lockheed, and RCA.

One other system appears very promising for undersea propulsion of torpedoes and sub-to-sub missiles. It is possible to arrive at ballistic-type trajectories underwater simply by ballasting. The "buoyancy" type ballistic missiles (BBM) need no powerplants, are noise-free, and are capable of relatively high speeds. BBM terminal phase speeds of 60 to 70 knots are possible.

**Importance of Structures**—In addition to higher propulsion performance, better structures and shapes must also evolve. With the trend toward greater depths and longer underwater cruise times, greater strengths and better corrosion resistance is required.

Modern subs first used ordinary steel plate. With lower depths and increasing pressures, high-strength steels may be called for. Of course, shape can help design somewhat. A significant future trend might be the increased use of the lighter metals. Reynolds Metals' "Aluminaut" is an example of a research vessel that will probe depths of 15,000 ft. Another undersea possibility is the use of magnesium. One serious contender in undersea use is plastics. Light, non-magnetic, and corrosion-resistant, glass fiber-plastic hulls would seem to offer structural densities only slightly greater than that of water. Couple the light metals and/or plastics with the buoyancy technique used in the bathyscape (where liquids are used to equalize the tremendous undersea pressures), add a touch of supersonic hydrodynamics, and you would have the analog of today's jet-propelled military aircraft — a supersonic sub or underwater missile. Since the velocity of sound in sea water is 4,700-4,950 ft/sec, this is an impressive goal to shoot for! By a combination of good design, light-weight materials, and say, a multi-stage rocket, there should be reason to expect supersonic underwater speeds in the future.

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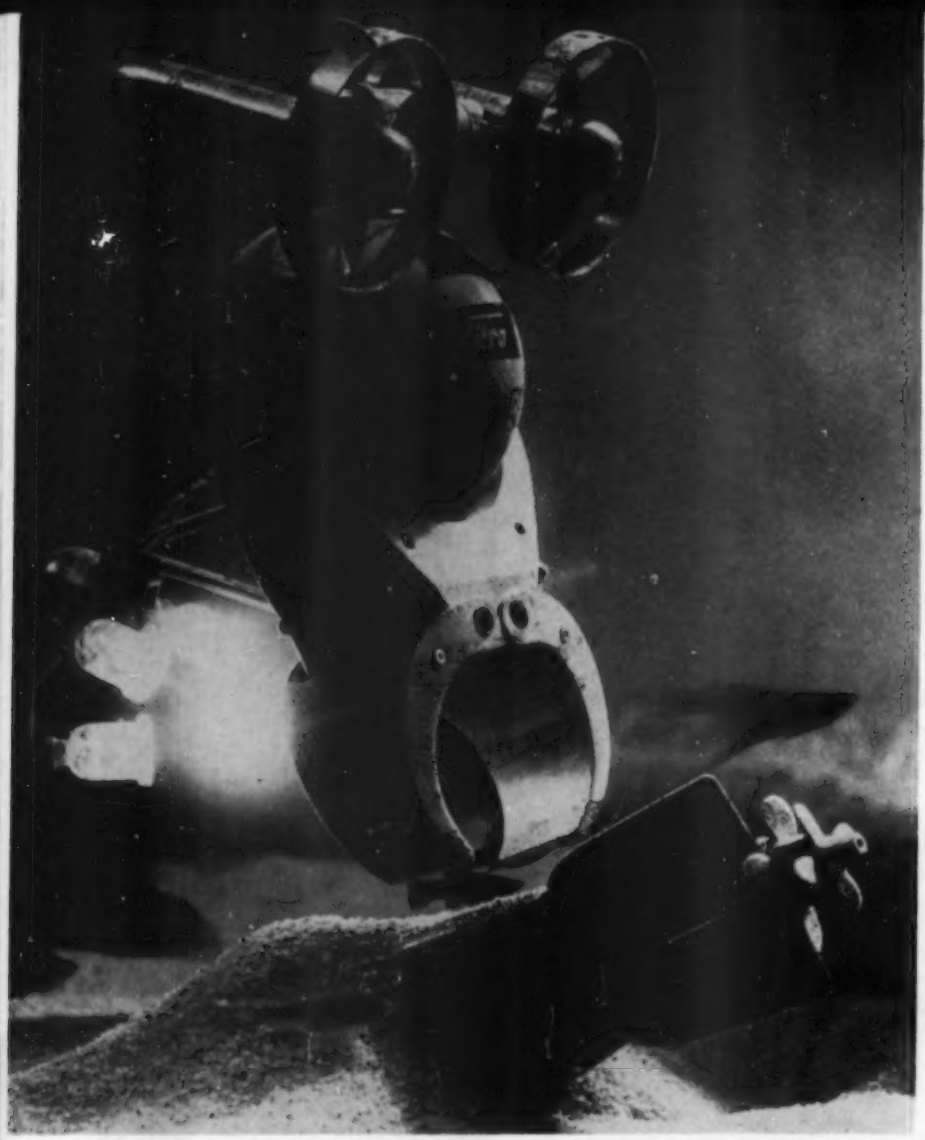
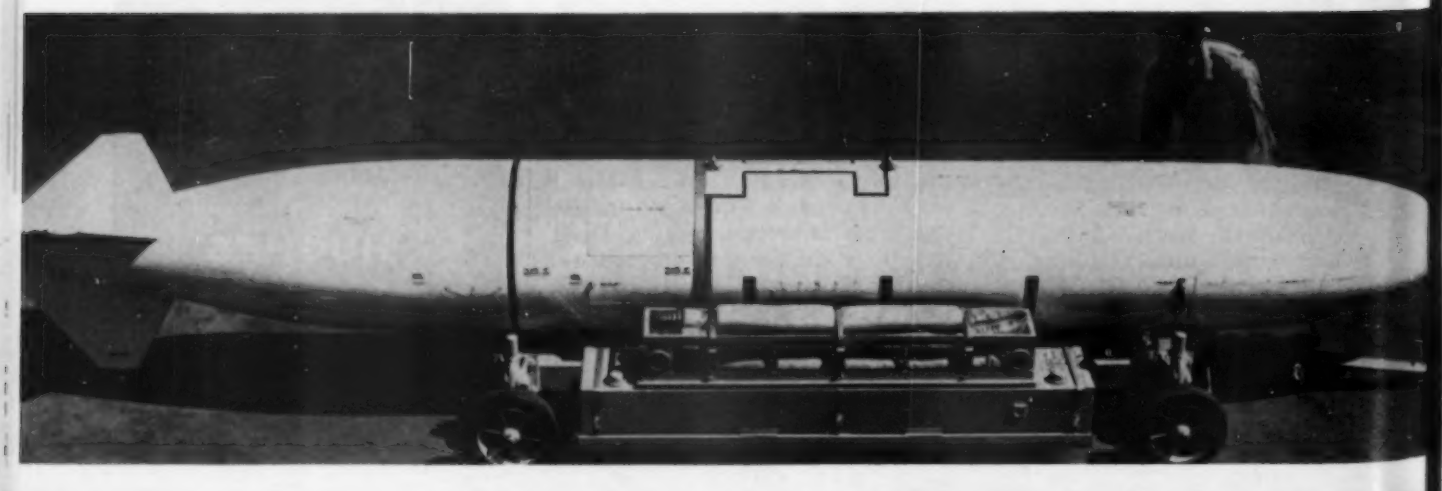
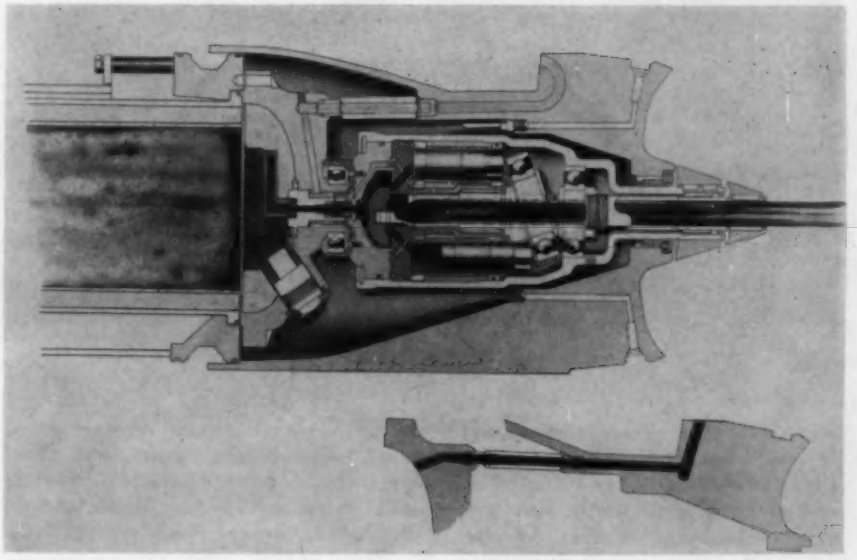
# torpedo briefs



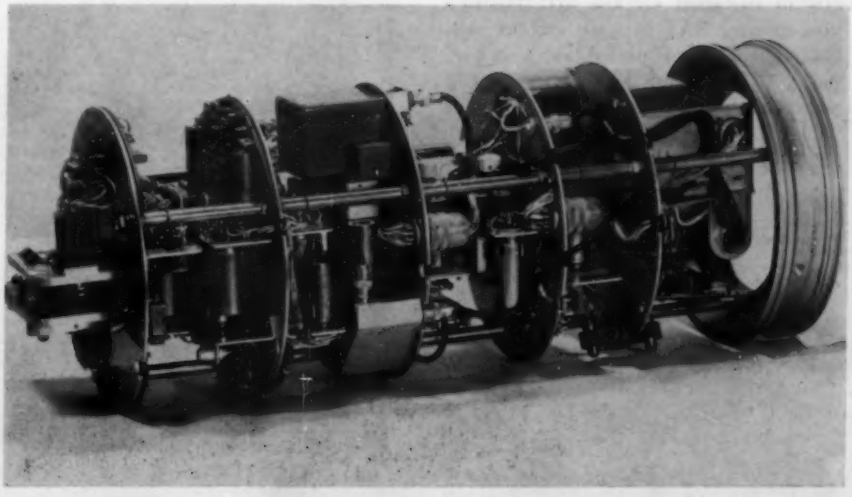
Recovering torpedoes from the Navy test range at Keyport, Wash., is one job assigned to Vitro Laboratories' SOLARIS robot, model of which is shown above. With its TV camera focused on the claw, the model is shown getting into position to recover the "fish." This one-eyed robot is designed to perform chores 2,000 ft deep. It slowly swims through the water, spots an object on the floor with its TV eye, and flashes the image to a surface shjp. Its shipboard masters can then guide SOLARIS to the object and make it clamp the object in its claw for retrieval. Below, peaceful torpedo (turbine driven power pod) built for the Navy by the Garrett Corp.'s AiResearch Manufacturing Div. The 26-ft long unit serves as a complete power package to keep Navy jets ready for emergency take-off. It can also fly along to advance fields, riding under an aircraft as do usual explosive-carrying torpedoes. Pod weighs 1,638 pounds; has 2.9 ft maximum diameter.



Control console aboard ship tells operator how deep SOLARIS is, and how far it is above ocean floor. It also reports the direction in which the robot is moving and presents a picture of what the underwater TV camera sees. Console shown here simulates picture of one SOLARIS watching another maneuver into position to recover a torpedo. Each of the robot's propellers is driven at constant speed of 420 rpm. Thrust is adjusted by varying pitch of propeller blades.



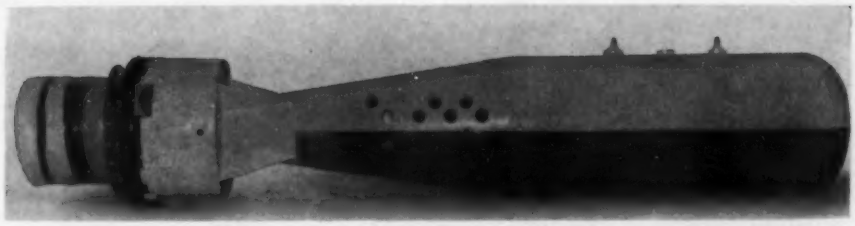
Torpedo propulsion against deeper diving and faster moving submarine targets has pressed the state of the art in materials, fuels, and engine design. Typical of the engines is Clevite Ordnance's swash plate design, right, which can deliver more than three hp per pound of engine and thrives on a diet of modified solid rocket fuel. Clevite strongly believes in torpedo design for function, as opposed to design for performance which has no measurable relationship to function.



Typical of today's designs in torpedo electronic sections is the Clevite Echo Elongater "Panel," right, which is in fact five plates tied into a modular assembly and suited to join other functional assemblies to handle any of today's sophisticated information generating and processing functions. "Panel" is a term growing out of the original Bell Telephone Labs torpedo amplifier designs, circa 1940, which were flat panels.

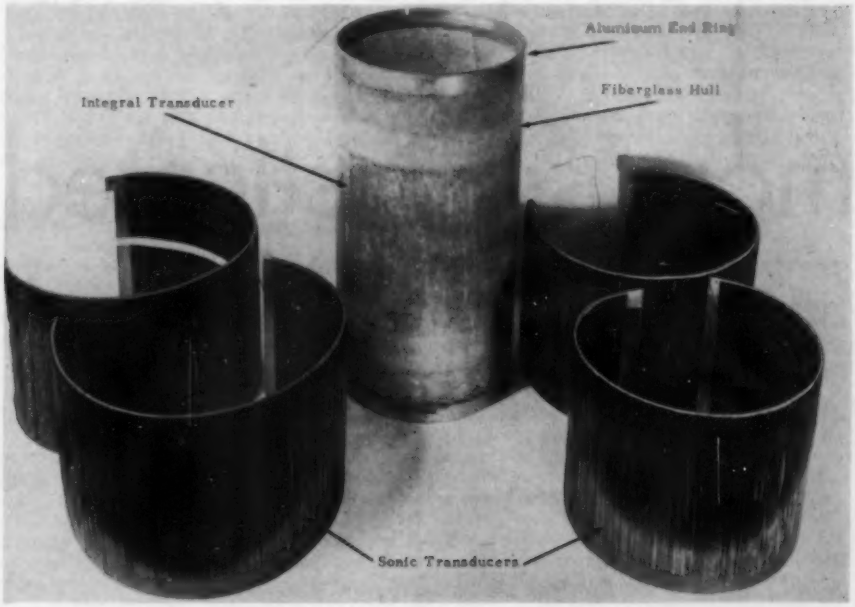
**The classical picture of the Navy gunner's mate waiting for the command, "fire." Here Chief Gunner's Mate A. A. de George awaits the signal to fire the Navy's light-weight, acoustic-homing torpedo from the deck of the Destroyer Escort *USS Tweedy*. As he waits, the skipper is conning the ship toward an "enemy" submarine, during ASW training exercises. The surface-launched homing torpedo improves the ASW capabilities of the surface fleet.**

***USS De Haven* is shown with the Rocket Assist Torpedo (RAT) launching system installed on the aft five-inch gun mount. RAT weapon system consists of rocket-propelled anti-sub torpedo, 13½ ft long and weighing 480 pounds.**



Air-dropped anti-submarine weapons must be lighter and smaller than surface-fired counterparts, withstand extreme environmental changes, and still produce the same results as comparable surface-fired weapons.

Navy anti-submarine weapon, rocket-propelled RAT, which incorporates rocket for initial launching, stabilizer pack with parachute to slow missile for proper water-entry speed, and a sound-operated homing torpedo, all held together by an airframe.




An example of modern torpedo design is the Clevite concept of hull design. Tough, resilient, polished housings are obtained by centrifugal castings of epoxy-fiberglass. Pictured above is a hull section with in-built transducer. Below, Navy's Astor torpedo is pulled from water following test runs at the Naval Torpedo Station, Keyport, Wash. Astor is an electric high-speed torpedo capable of destroying subs and surface vessels at long ranges. The sub-launched weapon was developed by Westinghouse, Baltimore.

# tomorrow's torpedo:

# faster, quieter, and more sophisticated

The torpedo has accounted for more enemy tonnage than any other weapon.

But the big problem today is the enemy submarine; and nearly everybody agrees that tomorrow's anti-submarine torpedo must be 1) faster, 2) quieter, 3) capable of greater range and search, and 4) idiot-proof.

**POLARIS submariners are now receiving closed circuit TV factory training on the operation and maintenance of POLARIS fire control and inertial guidance at General Electric's Ordnance Dept. in Pittsfield, Mass. Instructor R. E. Creamer, Jr. (left) conducts a class while in another part of the plant G. W. Maihl (right) keeps the TV camera on the lesson's subject.**

In other words, David's old slingshot may not be adequate to cope with the new Goliath.

The U.S. Navy today uses six makes of torpedoes, all of them launchable from destroyers, four of them from aircraft, and three from subs.

Several more advanced, sophisticated models are under research and development.

Underwater Engineering asked several of the nation's torpedo experts to give their views on "tomorrow's torpedo." Their comments are printed on these pages.

Although there is a variety of viewpoints, there appears to be common agreement on the need for greater speed, range, depth, and stealth.

Although they may not state it in so many words, experts probably agree that the biggest hurdle of all is *detection*. As one of them told UE, "The torpedoes work; our biggest problem is to know where the target is."

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Here is a balanced, objective analysis of the fundamental military problems presented by modern warfare . . . a book to stimulate thought, conversation, and action. No one who is concerned with airpower and its place in military strategy in the years ahead can afford to miss this important new book. Bookstore price $6.50.

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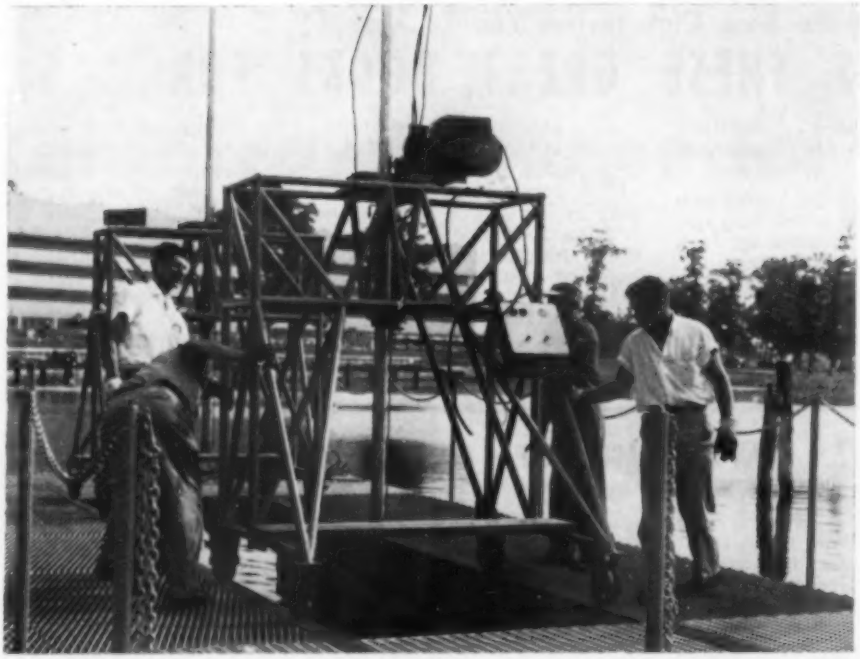

A raft-like platform for underwater acoustic measurements has been launched by the Martin Co. at Middle River, Md. Two transducers are mounted on electrically-controlled measurement shafts through the twenty ft by five ft access well to evaluate their effectiveness in detecting and classifying enemy submarines.

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Just as anti-air warfare requires mid-course guidance and terminal homing in the air environment, so we believe that anti-submarine warfare will always require mid-course and terminal guidance in the underwater environment.

The future underwater missile will be a vastly improved weapon. For higher speed it will employ boundary layer control and a jet system of propulsion, e.g., pump-jet or hydro-duct. Higher energy sources will provide power for this higher speed and greatly increased range while permitting operation down to bathyscaph depths.

A non-physical secure communication scheme will provide mid-course guidance while terminal homing systems will go lower in the frequency spectrum and have greater search capability.

*—James M. Beggs,*
*General Manager,*
*Ordnance Div.,*
*Westinghouse Electric Corp.*

The conventional underwater guided missile, known as the torpedo for the past 60 years, is now making its last desperate dying gasp for continued recognition. Speeds and depths of nuclear submarine targets are about to outrun the capabilities

Adm. Shane

of the ultimate chemical fuel for torpedoes, namely liquid hydrogen and liquid oxygen. Nuclear torpedo propulsion for the present may be ruled out due to the weight and cube of shielding requirements. The exotic weapons systems using a combination rocket-torpedo have become far too expensive to use except when the target has been fully classified with its range, course, speed and depth exactly determined.

The solution of this problem might be the electric cable powered and directed torpedo whereby the fuel and at least one-half of the propulsion equipment is carried in the firing ship. In such a torpedo only the breakaway head is expended; the delivery system returns to the ship for repetitive use. Many authorities in the electromotive field feel that an 8,000-v, 600-cycle, 1,000-hp plant can be produced to accomplish a 100-knot weapon within the dimensions of the conventional tor-

Mr. Beggs

Senator Jackson guides nuclear sub while Admiral Rickover looks on

pedo. The American Machine & Foundry Company has developed the concept for such a torpedo called the INVICTA.

*—RAdm. G. L. Shane, USN (Ret.),*
*Consultant on Undersea Warfare Systems,*
*Government Products Group,*
*American Machine & Foundry Co.*

Two years ago we predicted that within 20 years submarines would be operating at depths of more than 5,000 feet and would be making speeds up to 60 knots. I believe that this forecast is sound.

The torpedo is the original guided missile. The future submarine will need more than one weapon to cope with its future targets. The targets will be surface ships, submarines, long range land complexes, short range shore facilities, and aircraft.

Against these targets weapons may be fired from a submerged position. They might be called torpedoes but perhaps missiles would be a more descriptive term.

The anti-submarine weapon will need to be capable of operating at great depth. It will be acoustically guided. Therefore, it will need to be quiet enough to hear its adversary and fast enough to catch it. This suggests that speeds must be regulated by the strength of the target signal.

The United States POLARIS, SUBROC, and the Mark 46 torpedoes — all under development — qualify as forerunners of the future family of weapons. Spectacular improvements can be expected as the submarine's future potential is better understood by world powers.

*—VAdm. C. B. Momsen, USN (Ret.)*

I believe the torpedo of the future will be a guided underwater missile capable of unprecedented stealth, speed, and range in a three-dimensional ocean environment.

It will be capable of seeking out and destroying the enemy before he is aware of being under attack. It will be an integrated part of a sophisticated weapon system consisting of the weapon carrier and detection platform, and the target-sensing and fire-control equipment.

The underwater missile will itself be a part of the fire-control system and will thereby reduce system complexity while enhancing kill probability.

I further predict that sensory systems contained within the missile will be utilized in target classification.

The entire underwater missile weapon will be designed to utilize human capabilities to the maximum. Total numbers of personnel will be minimized and each will be fully integrated into the man-machine complex. Included in this approach will be complete adoption of the fixed-ammunition concept for the missiles.

*—Wayne G. Shaffer,*
*Director,*
*Vitro Laboratories*

The torpedo of the future should feature:

1) Modern concepts of design and materials, with structure and size set by function, not by yesterday's launching devices or yesterday's hulls.

2) Design for out-of-ship stowage. There is no good reason why the torpedo should take up expensive space inside a ship or submarine. There is no good reason why the torpedo tube could not be eliminated from the submarine or surface ship of tomorrow.

Mr. Shaffer

Mr. Lynch

3) Design for one-shot use. The torpedo of today is designed to be tested, not to be used. Consequently, it costs much more than it should, places severe demands upon the Fleet for repair and maintenance, and has a dependability factor which is set by the maintenance shop rather than by the design and production facility.

4) Design for function. There is presently a tendency toward designing for performance which has no measurable relationship to function. This may go so far as to use three gyros for control; it may be as trivial as the requirement for non-functional internal surface finish; but in all its forms it increases cost drastically and at no known gain in end function.

5) Design featuring a) solid state electronics, b) acceleration control instead of gyro control, and c) solid (potted) packing of elements and abandonment of the hollow shell concept (flooded structure).

The torpedo designed to the above general rules will be 1) more dependable, 2) less expensive, and 3) smaller and lighter.

*—Tom Lynch,*
*General Manager,*
*Clevite Ordnance Div.,*
*Clevite Corp.*

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Scientist Walter I. Whitman, ice forecaster aboard the U.S. nuclear sub Seadragon on its trans-polar voyage, takes weather data from bow of ship. Seadragon was first ship to negotiate Parry Channel through the Canadian Archipelago.

Senator Jackson holds Husky dog while inspecting Navy facilities in Antarctica as guest of RAdm. David M. Tyree, USN, commanding officer of Operation Deep Freeze 60.

# sen. jackson tells what's wrong...

*Senator Henry M. Jackson (D., Wash.) is a recognized defense expert, particularly in atomic energy and nuclear warfare. Aged 48, Senator Jackson—close friend of Democratic Presidential Nominee John F. Kennedy—is Chairman of the Military Applications Subcommittee of the Joint Congressional Committee on Atomic Energy, and was elected Chairman of the Democratic National Committee at the Los Angeles Convention in July.*

**Q.** *Senator, what are your hopes of our country's achieving a true POLARIS fleet?*

**A.** We can have a fleet of 100 POLARIS submarines in less than 10 years if we just assign sufficient priority to the job. I say less than 10 years out of the conviction that one submarine a month — 12 a year — is a realistic goal both in terms of financing and production.

**Q.** *You consider 100 subs sufficient?*

**A.** A minimum fleet of 100 POLARIS submarines "at the earliest possible date" has been my goal for the past three years. This is a minimum number — a starting point, if you will — when you consider the value of the weapons system, the progress we have made to date, and the enemy's submarine power and potential which must be countered. Any enemy attack would first be aimed at our ability to strike back. So long as the enemy is unable to destroy our retaliatory forces, so long as he knows we will be able to strike a counter blow after his attack, he will be hesitant to risk the initial attack.

Land-based missile sites are relatively large, relatively easy to identify, and fixed in place. The enemy likely would know the location of our land-based launching sites. A massive surprise missile attack might actually knock out all or most of our Strategic Air Force and much or all of our land-based missile capability before we could retaliate. This is why the emphasis is now being put on the need for constant airborne alert of SAC planes and on the mobile MINUTEMAN land-based missile which can be moved about on railroad cars, as well as buried deep in the earth.

**Q.** *So the POLARIS, in your opinion, is a superior weapon . . .*

**A.** The location of our POLARIS ocean missile force will change constantly. Our POLARIS submarines will be dispersed over millions of square miles of the oceans. Part of the force will be on submerged alert around the clock, 24 hours a day, 365 days a year, constantly on the move, a most difficult target to pinpoint and destroy. It will be able to survive a surprise attack and rain return destruction on the enemy's homeland. Steady advances are being made in submarine detection, of course. Yet finding ships under the sea is vastly more difficult than spotting planes in the air, or ships on the surface of the sea, since the scientific laws of radar do not apply. Then there is another point. Land-based missile sites and air bases are strategic magnets, drawing the enemy's missiles *toward* our cities and towns and farms and factories. Ocean-based platforms are strategic magnets drawing the enemy's missile fire *away* from our soil and the soil of our allies.

**Q.** *Should we give POLARIS to NATO?*

**A.** We must not overlook the appeal of the POLARIS system to our allies. Land-based airplane and missile bases on allied soil are just as prime a target for enemy missiles as land-based retaliatory sites on our own soil. Ocean-based striking power reduces the danger not only to our own homeland, but to the homelands of our allies. Reduced danger to their own soil should strengthen the will of allies and, for that matter, of neutrals, to resist the enemy's political and economic and psychological warfare, as well as to resist the enemy militarily.

**Q.** *What did you mean by "the progress made to date" when, generally speaking, you have been the sharpest critic of the Administration's progress on the POLARIS system?*

**A.** Your question really draws the distinction. Technical progress in developing the system has been impressive. Progress in terms of financial support and utmost production has lagged. I agree with the President, who said in his August 8 message to Congress that never before had such a complex weapons system been brought to operational stage in such a short time. That is all the more reason we should be pushing the production program faster, now.

**Q.** *Is Congress — generally — for POLARIS?*

**A.** Yes, I think it only fair to point out that the Congress has been far ahead of the Administration in pushing the POLARIS program. In Fiscal Year 1959, for instance, the Congress provided funds for four more POLARIS submarines than the Administration asked for. These funds were frozen by the President. The funds for one of the four were released about six months later; another six months went by before the Administration released funds for the remaining three submarines. This meant almost a year's delay on these three submarines! Again, in the Fiscal Year 1961 budget, the Administration originally asked for only three fully funded POLARIS submarines, and for funds for long-lead items on another three. The Congress provided money for five fully funded submarines and for long lead items on another seven. The Administration has now agreed to use the money for five fully funded submarines and for long lead items on another seven. It is still holding back the money for long lead items on two.

**Q.** *What about the Soviet's submarine power?*

**A.** Two years ago I appointed a special Underseas Warfare Advisory Panel to assist my Military Applications Subcommittee of the Joint Committee on Atomic Energy. Testimony and evidence at that time showed that the Soviet Union had built more than 300 submarines since World War II and had a force of about 475 submarines. By contrast, we had built less than 15 submarines since World War II and had an active fleet of 110 submarines, only three of them nuclear powered. Our report also pointed out that the Soviets have the capability to build many more nuclear submarines than we then planned to build.

**Q.** *Your advisory panel report contained a dozen or more recommendations. What happened to them?*

**A.** There has been some notable progress, I am happy to report, but there is still much room for improvement. Our report called for an initial task force of nine POLARIS submarines in the fiscal 1959 budget. The Administration failed to ask for them and, as I pointed out earlier, froze funds for the four Congress added. The POLARIS construction program is still lagging.

Our report called for a substantial increase in the number of attack submarines. At that time the Navy planned to have 13 nuclear-powered attack submarines in operation by the end of 1960. We now have six in operation and 20 in various stages of construction. A total of 30 has been authorized and funded. This year the Administration asked for only one nuclear attack submarine, and the Congress provided for four. The funds for the additional three again have been frozen.

Our report called for at least doubling the fiscal 1959 Navy research and development budget for systems immediately relevant to undersea warfare. We came close. The Navy programmed $172 million for this in fiscal 1959 compared to $104 million in fiscal 1958. The figures for 1960 and 1961, respectively, are: $217 million and $196 million.

Our report called for a substantial and continuing increase in the Navy's budget for basic research not immediately related to operational requirements. That figure has gone up from $49 million in fiscal 1951 to $54 million in fiscal 1960, and $63 million in fiscal 1961.

Our report called for increased financial support for basic research in oceanography. The Navy's dollar figure for this purpose has gone up from $9.4 million in fiscal 1959 to $13.9 million in 1960 and $17.7 million in fiscal 1961.

Our report called for additional funds for oceanographic survey work. These funds, too, have been increased from $23.5 million in fiscal 1959 to $33 million in fiscal 1960 and $36.6 million in fiscal 1961.

And, very important, we recommended that the POLARIS system, for funding purposes, be removed from the Navy's shipbuilding budget, and that construction budget requests for the POLARIS system should be determined by the Secretary of Defense and the National Security Council as part of our overall strategic deterrent budget. This was not done and still has not been done.

**Q.** *What was the reason for this last recommendation?*

**A.** The Navy's regular shipbuilding budget covers carriers, cruisers, frigates, destroyers, tenders, mine sweepers and all the other vessels employed by our Navy. A POLARIS-launching submarine is thus treated fiscally like any other naval vessel. In terms of its military mission, however, it is radically different from other ships in the fleet. Actually, the POLARIS system is part of our national military deterrent against all-out war. It is an instrument of strategic reprisal. It is more analogous to a SAC bomber, or a land-based IRBM or ICBM, than to other ships of our Navy.

Under existing funding regulations, POLARIS submarines must compete for money with the rest of our shipbuilding program. This total construction budget is limited. Even if none of this money were spent on POLARIS submarines the funds would be stretched to the limit in meeting the Navy's requirements for its traditional mission of controlling the seas. From the standpoint of national deterrent strategy, then, the POLARIS system should not be treated as part of our regular shipbuilding program.

**Q.** *Are you also interested in advancing our ASW research?*

**A.** By all means. Our report specified five critical areas for more vigorous prosecution. These included 1) development of systems to utilize underwater sound phenomena, 2) communications, 3) oceanographic surveys, 4) compact nuclear reactors, and 5) experimental ships.

**Q.** *What do you mean by experimental ships?*

**A.** The Navy rarely has built experimental ships. Yet a program of design and construction of such ships, in order to study their performance characteristics and operational potentialities, should yield very large returns. To cite just one example, such a program might include different true submarines (rather than submersibles) such as heavier-than-water submarines using controllable planes to maintain depth. In addition to a stepped up *applied* research and development effort, it is essential also that the Navy continue to increase its *basic* research.

**Q.** *What is the role of basic oceanographic research in the underseas warfare picture?*

**A.** Immense. The operational use of nuclear powered, deep-running submarines and the development of counter measures against them, including detection, identification, tracking and attack, will inevitably require a far greater knowledge of the ocean waters and the underlying sea floor than we now possess.

**Q.** *For example . . .*

**A.** At present, we have only roughly accurate maps of the deep sea floor for about two per cent of the total ocean area. The underseas Navy also must be prepared to operate off the coasts of any part of the earth. This requires a working knowledge of environmental, meteorologic, oceanographic and topographic conditions in offshore areas throughout the world which is at least as good as that of our potential enemies.

**Q.** *What is being done in this field?*

**A.** Not enough. A committee of the National Academy of Sciences has estimated that it would take 10 years, with 15 to 30 deep sea vessels, at a total cost of $20 million to $30 million a year, to accomplish the most essential surveys. This work could be done by the existing surveying agencies of the Federal Government.

Oceanographic surveys should of course, be distinguished from oceanographic research, which is the study of the fundamental properties of the ocean's waters and its bottom. An accelerated oceanographic research program is no less needed than a stepped-up survey program.

**Q.** *Is Congress pushing such programs?*

**A.** In this connection, there are two developments in the making which could produce vastly important results. The first is the Marine Sciences and Research Act, S. 2692, sponsored by my Washington State senior colleague, Sen. Warren G. Magnuson. It would double, within 10 years, our facilities for scientific research on and in the ocean, and it would double the number of scientists trained for this work. The bill passed the Senate this past session, but not the House. It is my hope that this important legislation can be enacted into law in the near future.

A second significant development is the proposal before the NATO Council for a series of NATO oceanographic expeditions. This proposal was advanced by last year's NATO Parliamentarians' Conference on the grounds that much talent available in NATO countries is now going to waste. Many NATO countries have excellent potential in marine science, but the high costs of research laboratories, ships, and other modern techniques have deprived them of the opportunity for up-to-date experience. The proposal for NATO expeditions foresees the use of one or more of the most advanced oceanographic ships now available in the NATO Community, with all NATO countries invited to designate marine scientists to join the expeditions. In this way new ideas would be developed and vital research advanced. At the same time scientists from many NATO countries would gain the experience they need to help develop national and cooperative efforts in this vital field. Again, it is my hope that the NATO Council will act quickly to approve such expeditions.

**Q.** *What would you say is the most important single development in oceanography and underseas warfare to date?*

**A.** That's an easy one — the growing public awareness of the importance of both to our nation's survival. This awakening by leaders in government and by the general public is resulting in increasing support for the necessary programs to make the oceans work for us, rather than against us.

Raytheon's new fully-integrated ASW center.

# asw research at raytheon

*By RAdm. P. D. Gallery, USN (Ret.)*

A new industrial center devoted entirely to anti-submarine warfare (ASW) is in operation at Portsmouth, R.I., as an integrated facility of Raytheon Co., well-known electronics and systems contractor.

This facility, costing eventually about $4 million, is the culmination of Raytheon's growth in the underwater field that started with its acquisition in 1946 of the Submarine Signal Co. The center will be fully integrated — an autonomous organization for design, development, production, marketing, and administrative facilities. It was formally opened on July 18, 1960.

Charles F. Adams, Chairman of the Board of Raytheon, made this statement in observance of the opening:

"Raytheon Company, recognizing the threat to our country by enemy submarines, decided in 1958 to establish a fully integrated industrial facility devoted to all phases of ASW. This new facility will be staffed by scientific, technical and production personnel whose talents will be devoted exclusively to the ASW-USW (undersea warfare) problem. This new operation will be able to develop and place into production the latest types of ASW electronic equipment in a minimum of time. I believe that Raytheon has taken a major step in making this new facility available to the aid of the defense of our country."

Roger Hamel, General Manager of the new center, points out that among the advantages are "acceleration of availability of up-to-date equipment to the Navy and the center's proximity to Naval ASW laboratories and equipment, helping conformity of our development work with the Navy's requirements."

Besides Mr. Hamel, the following are some of the key managers of the new facility: M. S. Wilson, Engineering; R. W. Stout, Manufacturing; E. E. Turner, Advanced Development; E. P. DiGiannantenio, Marketing; and E. D. McDonald, Programs. About 600 men are initially being assigned to the 135,000-sq ft plant. This number is expected to grow to 1,500 when additions are made for production which will triple the floor space in the next two years, according to present plans. The "proximity to Naval ASW laboratories" mentioned by Mr. Hamel is shown in this list of neighbors only a few miles away: Destroyer Force Atlantic Headquarters, Submarine Force Atlantic Headquarters, Quonset Naval Air Station, Destroyer Development Group Two, Submarine Development Group Two, Underwater Ordnance Station, Underwater Sound Laboratory.

The physical plant is situated about 100 yards from Narragansett Bay, with dock facilities for Raytheon's experimental test boat *Alan* and other craft used in operational tests. A fresh water reservoir on Raytheon property is also available for outdoor test use.

A most important point regarding the integration of all steps in design and producing equipment is "acceleration of availability." The fleet for years has chafed under the slowness of translating a good idea into hardware in the fleet.

The company is active in the following underwater fields:

*Submarine Sonar* — Raytheon developed and is producing the world's first fully hull-integrated detecting system and secure communication system for nuclear attack submarines.

*Airborne Sonar* — Submarine Signal has developed a new system transistorized to meet very lightweight specifications, using selected frequencies. Involved is a unique combination of beam patterns making possible both range and bearing determinations, with simultaneous coverage of all targets in azimuth.

*Shipborne Sonar* — Raytheon is working on adaptations of its operational airborne equipment and recent helicopter proposal to provide the Navy with a variable depth sonar that is small and light, yet of appreciable range. Such a sonar is greatly needed — the first prototypes of VDS were enormously bulky and unwieldy while the small ones did not give satisfactory ranges. Any towed sonar has the possibility of "beating the layer" by proper

**E. D. McDonald, Operations Manager, Programs.**

**W. Rogers Hamel, General Manager, Submarine Signal Operation.**

**Robert W. Stout, Operations Manager, Manufacturing.**

**E. E. Turner, responsible for Advanced Development programs.**

positioning and decreasing the effects of quenching experienced by ASW surface vessels in any kind of seaway.

Raytheon's North Dighton, Mass., facility is quantity-producing devices for realistic training of sonar operators on board ship. An unusual feature of the equipment is its ability to accomplish training without interrupting normal operations of the ship's sonar.

Raytheon's experience with ultrasonics in underwater projects contributed to the development of an untrasonic cleaner for aircraft engines and other equipment.

Submarine Signal developed equipment for civilian as well as military use, an example being the acoustic flowmeter. This device gives accurate measurement of water flow in rivers and streams, supplying answers to such problems as pollution, erosion, and flood control.

With 60 years of background experience in underwater detection and location equipment, the company has developed many components such as transducers and hydrophones which are furnished to other suppliers of ASW systems.

The engineering facilities of the center will permit carrying out an R&D program from the inception of the basic concept to prototype model. The addition of manufacturing and production facilities by 1963 will enable the center to carry right through to delivery to the fleet in production lots.

Test facilities include a sonar test tank with a capacity of 180,000 gal in depths from 20 to 24 ft. This L-shaped tank has been designed and equipped for optimum control as well as expeditious handling of a wide range of test and experimental projects. Its shape will permit an engineer to work on one project without the necessity of expending time to dismantle and set up another; it will also allow concurrent runs of both high and low frequency measurements. Power supply to the tank is obtained from three drivers operating below 100 cycles up to the megacycle range. An isolated hydroacoustic test bed with transmission line to the tank also provides an excellent capability for developmental work with hydroacoustic sound sources.

An important adjunct to the test equipment at the center is the world's most completely equipped mobile sonar test unit — the test boat *Alan*. This craft has two deck houses fitted as a laboratory, a 2,600-pound electric hoist, a sea chest tube containing a 6-in. diameter stainless steel training shaft for transducers, plus other research and test apparatus.

The equipment in use today is a far cry from the devices produced by and primitive means available to the old Submarine Signal Co. Nevertheless, the Submarine Signal Co. Bell for Navigation, the Fessenden Oscillator (developed by Sub Sig's Professor Fessenden), World War I hydrophones, the Fathometer® and early detection devices all played their vital roles in the advancement of underwater technology. They all originated, at least in part, with Sub Sig. Successful detection and ranging on icebergs after the *Titanic* sinking in 1912 was a development by Sub Sig that led to today's sonar. There are still many old-timers from Sub Sig with Raytheon — notably Senior Vice President Percy Spencer, eminent radar scientist and developer of the famed Magnetron.

Raytheon is one of the largest electronic companies in the world, with 12 divisions in nine states and Canada, employing 41,000 people. In 1959 sales of $494 million placed the company among the 100 largest in the nation in sales. Raytheon is the largest single employer in the state of Massachusetts.

The tremendous increase in size of the Soviet submarine fleet, the polar exploits of our *Nautilus* and *Seawolf*, the submerged round-the-world cruise of the *Triton* and the advent of the POLARIS missile firing submarine all combine to lend added importance to Raytheon's increased effort in the ASW field.

# britain's role in marine science

**By Dr. G. E. R. Deacon, F.R.S.**
***Director of the National Institute of Oceanography, England***

It is often said that systematic study of the oceans started with the round-the-world voyage of Her Majesty's Ship *Challenger* in 1872-76, but its narrative pays tribute to earlier workers.

"The methods," it says, "were crude, but they sometimes contained the germs of great ideas; the results arrived at were often erroneous, but they were steps in the right direction; and the researches were animated by the true scientific spirit, the spirit of observation and inquiry."

But the 19th century was a great era for scientific exploration, not the least the exploration of the sea. Twelve of the 25 main voyages of exploration were British. William Scoresby made careful observations on water and ice conditions, plankton and whales in the Arctic Ocean. Parry and Sir John Ross also worked there. The voyage of the *Adventure* and the *Beagle* with Captain Fitzroy and Charles Darwin was made soon after and then "the voyage of discovery and research in the Southern and Antarctic regions" by Sir James Clark Ross in the ships *Erebus* and *Terror*. This expedition was quite remarkable for the amount of astronomical, physical, botanical and zoological work as well as for its magnetic studies and exploration of the Antarctic.

**Marine Zoology School** — At the same time Forbes was pioneering in marine zoology and building up an active school in Edinburgh. Wyville Thomson, who was scientific director of the round-the-world *Challenger* expedition (1872-76), followed him 20 years later.

The Royal Society (The Royal Society of London for the Promotion of Natural Knowledge) had much to do with all these voyages. It made the appeals to the Government and set its committees to work on the plans. The *Challenger* expedition was on a really grand scale. When it returned, an office was set up to complete the reports, 50 large volumes, taking 20 years.

Lord Kelvin made outstanding contributions to marine science. He dealt with the effect of thermodynamic and geostrophic forces on water movements as well as many practical inventions for navigation, ocean sounding, tide prediction and cable laying. Other prominent theoretical workers were Green, Airy, Young, Rayleigh, Stokes, Lamb and Reynolds. They seem to have had little influence on oceanographers such as Carpenter and Buchan, who had most to write about ocean circulation.

While rather slow progress was made with the ocean itself, much was done for navigation. Early in the century Rennell compiled a very thorough account of the currents of the Atlantic Ocean and, in 1853, largely owing to efforts of Lt. Maury, U.S. Navy, the principal maritime nations started to set up meteorological offices to collect systematic observations of winds and currents from all parts of the world.

**Elements Reduced to Subjection**— All this growing experience and enthusiasm made Admiral Smyth write: "The various branches of available science have been so steadily advancing among seamen of all nations that besides higher practice in mechanical navigation they possess a more accurate information respecting the phenomena of winds and oceanic currents than heretofore. Already the elements are nearly reduced to subjection by the union of science and practical seamanship so that sea passages are wonderfully shortened within memory."

The problems today seem much more difficult. Voyages can no longer be shortened by two or three weeks, but the greatly increased volume of traffic makes it just as valuable to save a tide, to reduce loss and damage, and to lessen the cost of keeping ports open to ships of ever increasing size. These are too difficult to be solved by simple plotting and charting of observations. Science is the basis of engineering and the new problems need detailed study, using theoretical and practical techniques as advanced as those of all other industries.

Advances in the first 50 years of the present century seem to have been stimulated not so much by the needs of navigation as by fishery problems. Nations around seas in which fisheries were expanding so rapidly as to raise alarm about overfishing joined to obtain reliable information that could be used to judge what should be done. Each country needed the best information it could get.

In Britain it led to the growth of fisheries laboratories, marine biological associations and marine biological laboratories in the universities, and to a great wealth of biological study in British coastal waters and on arctic fishing grounds.

**Investigating The Whale** — The *Discovery* Investigations, begun in 1924 to gain information about antarctic whale populations, was a similar development. It started with an almost unknown ocean and had to look for all the background knowledge about water conditions, currents, fertility, plankton and es-

**Ship's cat watches as Dr. J. C. Swallow, British oceanographer, loads batteries and transmitter into neutrally-buoyant float aboard Discovery II. Float is used for deep current measuring operations.**

pecially the whale food, that would help and strengthen the interpretation of the whale observations.

The physical data and biological collections are even greater than those of the *Challenger* and will take longer to study because they are comprehensive and systematic enough to allow detailed study of the life-histories, spawning, growth and feeding habits of some of the plankton species.

Thirty volumes of reports published so far include generalizations about water movements and distribution of whales and plankton as well as the systematic and population studies.

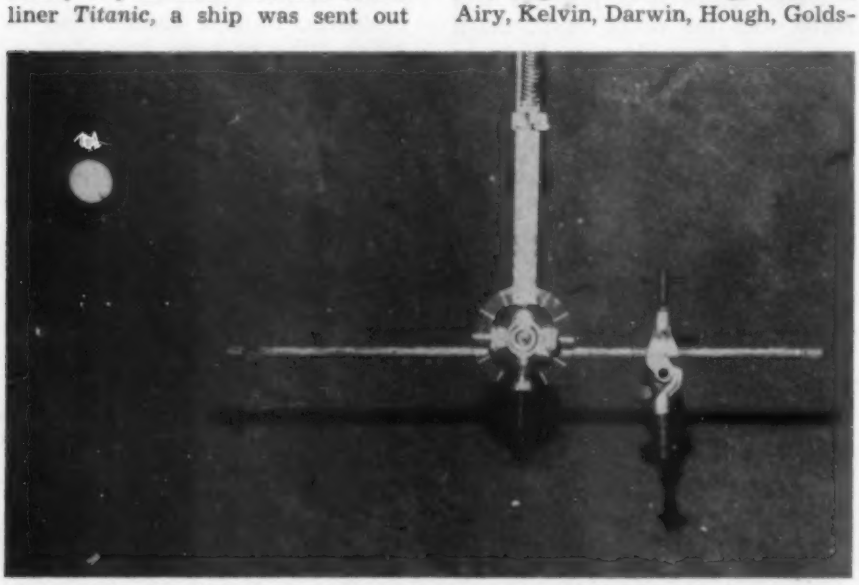
Ice hazards to navigation started one expedition. In March, 1913, nearly a year after the loss of the liner *Titanic*, a ship was sent out with very competent scientific observers, D. J. Matthews and G. I. Taylor, to judge whether steps could be taken to make the steamship routes across the Atlantic Ocean safer by establishing ice patrol vessels farther north.

The cost of the expedition was shared by shipowners and the United Kingdom Government, and the findings, considered at a conference on the safety of life at sea held the same year, led to the establishment of an international ice patrol, now run by the U.S. Coast and Geodetic Survey. The theoretical and practical study of tides has given direct benefit to navigation.

**Exciting Problems** — In Britain the most prominent workers since Newton's time are Young, Whewell, Airy, Kelvin, Darwin, Hough, Goldsbrough, Proudman and Doodson. It was largely owing to Proudman that the Tidal Institute was established in 1919 in the University of Liverpool. It was later combined with the Liverpool Observatory under the Mersey Dock and Harbor Board, directed since 1945 by Doodson, who had helped Proudman since the start. It has made very important contributions to the difficult task of explaining the complex systems of tides that exist in actual seas and oceans, and to the skillful methods of handling data needed to produce accurate tide predictions.

Much has been done and with facilities on a much more modest scale than those available to any other industry. Seafaring men do not really understand what science can do and scientists are not yet aware of the exciting problems in the sea. Thousands of ships suffer loss and damage every year, and enormous sums are spent every year to protect coasts and to maintain harbors, but there is not much demand for more science until some of the problems get out of hand in a war or in some other spectacular catastrophe. There was no really practical instrument for making continuous records of waves until 1944.

The first thing a scientist would do when studying a mixture of light, sound or radio waves would be to find its spectral composition, but for sea waves this was not done until 1945. It allowed Barber, Ursell, Darbyshire and Tucker at the Admiralty Research Laboratory, Teddington, Middlesex, to show that sea waves behave as though they originated in a large number of instantaneous point disturbances distrib-



**Picture taken by deep-sea camera mounted at top of tripod, with compass and table tennis ball fixed below. This British device gives direction and velocity of bottom current below Gulf Stream through compass reading and deflection of ball.**

*This article was contributed to Underwater Engineering through the British Information Services.*

uted over the storm area so that there is a continuous spectrum of wavelengths whose upper limit depends on the speed of the wind, and a wave pattern that is at any time the sum of a large number of component wave trains.

**Threshold of Developments** — Since then another British scientist, Longuet-Higgins, has shown that the component wave trains behave as though they have random phase relationships and this allows the statistical distribution of such features as velocities, intervals between crests, slopes and length and direction of wave contours to be determined with remarkable accuracy. It is a fine continuation of the careful, though over-simplified, theoretical studies of earlier workers such as Stokes, Kelvin, Rayleigh and Lamb in this country and Cauchy, Poisson and others abroad.

Tucker has described a wave recorder that can be fitted in ships, and it has been used successfully over the past seven years. It makes some compromise, accepting some limitations to achieve simplicity and robustness, but has not so far been improved on. Ship motions can be analyzed in the same way as waves, and Cartwright and Rydill have shown that spectra of roll, pitch and heave are closely related to the wave spectra, so that the probabilities of different accelerations and stresses can be calculated. These advances, together with growing understanding of the sea surface, and the availability of electronic computers, have brought us to the threshold of developments that will have great influence on future ships.

Another interesting outcome of the spectrum-analysis approach to sea wave studies is a clear demonstration that interference patterns of sea waves can communicate sufficient energy to the sea floor to account for the microseismic oscillations of three to 10 sec that form a continuous background, greater in winter than in summer, on seismograph records.

The theory is well supported by observations, and as far as possible by experiment. It is not yet universally accepted, but with the help of further analyzing and correlating equipment it can be used to obtain information about ocean storms and oncoming swell without going near the sea.

It may prove useful in countries that border on large oceans with poor meteorological cover. It has some interest in relation to the effect of deep explosions, and it may afford a means of studying geological features under oceans and land.

**National Institute Formed** — New advances are being made in the study of the transport of water by waves. They begin to add materially to our understanding of beach currents and of the factors likely to influence coastal erosion, transport of sediment and formation of submarine bars.

Much of this work had its beginning in wartime requirements. Since the war, it has been continued in the National Institute of Oceanography, founded in 1949 to supplement the work of the fishery and marine laboratories by detailed studies of the physics of the oceans. It also studies the plant and animal life outside the coastal region and main fishing grounds.

The Institute is controlled by the National Oceanographic Council, which was granted a Royal Charter, and operates with the aid of Government grants. The emphasis of its program is on long-term research.

The nucleus of physicists came from the Admiralty Research Laboratory, and of biologists from the *Discovery* Investigations. Useful progress has been made and new tasks taken on, such as study of the sea floor and of the active movements of water and sediment that sometimes occur even at very great depths. There are many remarkable gaps in our knowledge of the sea. The specific heat of sea-water had not been measured since 1889, and a new series of measurements using modern techniques has proved well worth while.

There are interesting and important chemical problems. By 1819 a London doctor, Marcet, went so far as to say that the principal constituents of the dissolved salt are present in the same proportions to each other all over the world. He had only 14 samples, but much more extensive work by Forchhammer in Denmark and Dittmar, who analyzed *Challenger* samples in Glasgow, did not prove him wrong.

The small differences that can now be detected, especially in radioactive substances which do not last long enough to be mixed with the ordinary constituents to the same degree all over the world, provide interesting problems. Atkins and Harvey, of the Plymouth laboratory, roused interest in the study of nutrient cycles in the sea, and much more, including the occurrence and effect of trace elements, has been done.

**Study of Ocean Circulation** — The joint theoretical and practical study of ocean circulation, so long in need of special attention, seems to be making good progress. The quantitative study began with calculations based on pressure distributions in the ocean, using a method similar to that used to deduce wind speeds from the spacing of isobars in weather maps. But it gives relative figures, and the final interpretation depends on knowing the speed at any one depth.

The earliest device was to assume that the water at the bottom of the sea was motionless. Later it was proved more reasonable to assume that there was least horizontal motion at the depth where the isobaric surfaces at neighboring observations points were most nearly parallel. There was urgent need of actual measurements, and those made from ships anchored in deep water were not reliable enough.

The National Institute of Oceanography tried to plot the descent of slowly sinking acoustic transmitters in much the same way as meteorologists follow ascending balloons using acoustic apparatus instead of theodolites or radar. It proved too difficult, but Dr. Swallow devised a much more practical method. He mounted the transmitter on a float which is less compressible than sea-water. If such a float is made slightly heavier than the same volume of sea-water at the surface, the density difference decreases as the float sinks until, at some predetermined depth where the float has the same density as the water, it sinks no farther but drifts horizontally with the current. The acoustic transmitter can be followed by a surface ship fitted with hydrophones.

**Very Exciting Work** — More and more of this sort of work is being done and strong and often variable subsurface and deep currents are being found and studied. Most of it is being done by British and American scientists in close cooperaton. None of their theories is completely successful, but there is often sufficient agreement with measurements to make the work very exciting.

Research is particularly important because the great size and variability of the oceans will make our few observations ineffective until we have as much guidance as possible from physical and biological principles. But there is still much exploratory work to do and British ships made useful contributions during the recent great joint effort of the International Geophysical Year.

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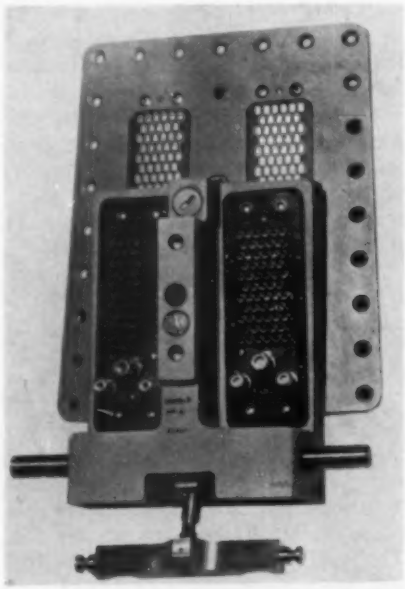
# new ue products

## Unique Umbilical Connector

A unique electrical umbilical connector which disconnects by shearing action, developed by E. B. Wiggins Oil Tool Co., Inc., is being used to activate the Navy's POLARIS missile into controlled power flight from its underwater launching submarine.

Integrated into one compact connector plug which mates with an



airborne receptacle are 126 pins (4 through 20 contact size) with spring leaf contacts and two 1/2-in. water methanol electronic cooling lines.

Upward movement of the missile disconnects the umbilical during launching and causes retraction of the connector into a cavity within the launch tube. The connecting surface of the receptacle (missile half) is electrically isolated upon disconnection.

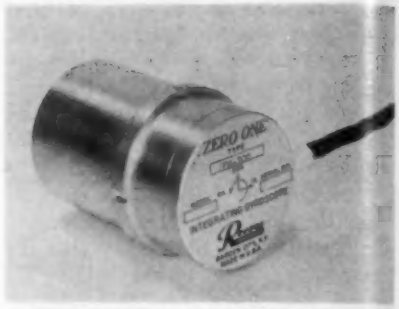
**Circle Reply Card No. 106**

## Miniature Floated Gyros

New miniature floated gyros have recently been developed by Reeves Instrument Corp. and United Aircraft Corp.

Reeves, a subsidiary of Dynamics Corp. of America, has developed a new series of high precision miniature floated gyros with a trimmed drift rate of less than 0.01 degrees per hour. Identified as the Zero One series, these gyros have an angular momentum of 300,000 c.g.s. units and a mass unbalance of less than 0.4 degrees per hour per gram.

The gyro case is 1.8 in. in diameter,




and the total weight of the unit is approximately one-half pound. Their small size and light weight, the manufacturer states, make these gyros ideally suited for missile guidance, stabilization, and other airborne applications where extreme reliability and accuracy along with space and weight considerations are paramount.

**Circle Reply Card No. 101**

United Aircraft Corp.'s Norden Div. announced the development of a new miniature floated rate integrating gyro designated the RI-203.

Features of the new gyro include low drift rate (random drift less than .02 degrees per hour), excellent day-to-day stability (.10 degrees per hour without trimming) and an unusually long life of 3,000 hours. According to the manufacturer, the low drift has been achieved with a spin motor turning at only 12,000 rpm, which insures the longer life. Only 3.1 in. long by 2 in. in diameter, this guidance gyro, including heater and shields, weighs one pound.

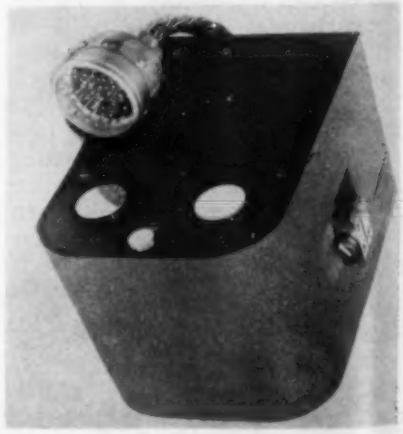
Its applications include inertial navigation and guidance for missiles and aircraft, stabilization of shipboard devices, and others which require precise angular measurement.

**Circle Reply Card No. 102**

## High Gravity Recording Oscillograph

Midwestern Instruments has announced the development of a high-gravity recording oscillograph, designated Model 560A.

This oscillograph, according to



Midwestern, is capable of recording 14 different data traces on 3-5/8 in. wide record paper or film. Weighing less than 10 pounds, it can be installed inside missiles, torpedoes, or other such units. Records of component performance, shock signatures, and other needed research data are made on board the test vehicle.

**Circle Reply Card No. 103**

## Severed Underwater Cable

Boston Insulated Wire & Cable Co. has announced the development of a new severed underwater cable. This new construction prevents the passage of water through the cable from one compartment to another, even though the cable be severely

damaged or cut on the seaward side of the bulkhead. According to the manufacturer, pressures on the exposed end will withstand 1,000 psi in conformance with the hydrostatic test of Mil-C-915A, Amendment 8. Multiconductor and coaxial constructions are available for POLARIS submarines and all deep water applications.

**Circle Reply Card No. 104**

## Variable Ratio Transmission

Development of a mechanical variable ratio transmission that incorporates features not available in conventional gear boxes has been announced by the Lycoming Div. of the Avco Corp.

The transmission is the variable ratio drive section of a 65 hp constant speed drive. According to Lycoming, efficiency is more than 90 per cent over the full speed range. This approaches good gear box efficiency and means that less horsepower is required to drive the unit for a given output.

Outstanding features are an infinitely variable speed ratio, operation in extremely high or low ambient temperatures (from —65 degrees F. to 600 degrees F.), and simple, compact design.

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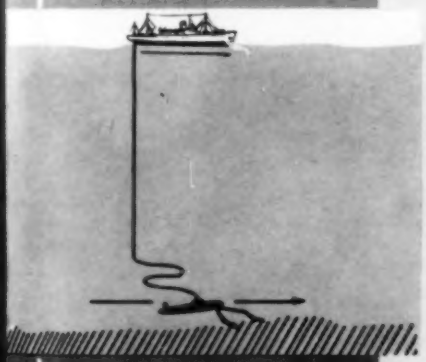
# USI Reports on

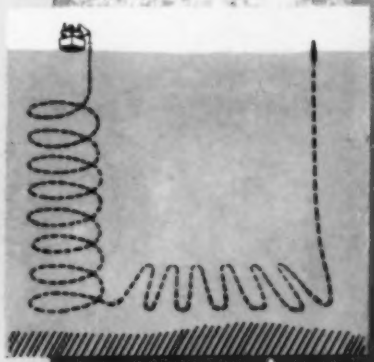
## Five current projects on MECHANICAL EQUIPMENT for oceanographic research

***FOIF—Free Oceanographic Instrument Float.** Now undergoing deep sea testing, this float follows a free flight trajectory to the depths and return. By freeing the instrumentation from its connection to the mother ship, data gathering is far more efficient and faster.

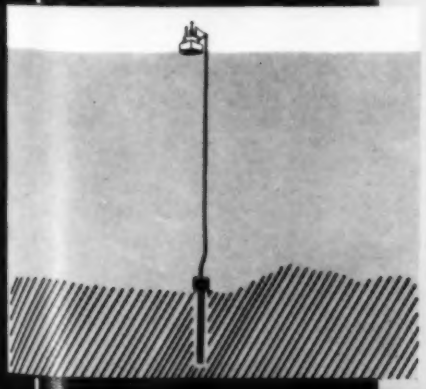


**GRAPPLING SYSTEMS.** A self contained, self propelled, remotely controlled grappling device for ocean floor work. Utilizing closed circuit television and light arrays, the oceanographer can search out and gather samples selectively with this mechanical hand. Also, suitable for attachment to bathyscaphes and deep diving submarines.

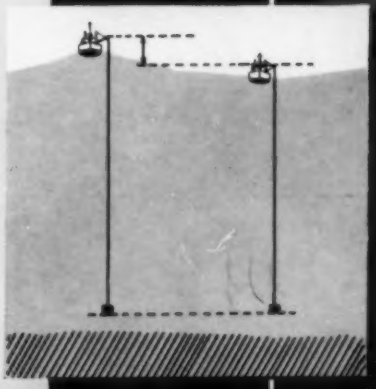
**DUMS—DEEP UNMANNED SUBMERSIBLES.** A new self propelled, deep diving unmanned submersible which follows a pre-set course to any depth for durations of four hours. Consisting of a fiber glass case and self contained jet drive power package, DUMS will collect data throughout large volumes of the ocean.



**DEEP CORING DEVICE.** Using a new principle in coring, this deep self powered corer can obtain long undisturbed cores of the basin sediments. Dropped freely, or cable lowered, the corer will level itself, collect a 200 ft. sample from one location in a vertical direction, and then return to the surface.



**CONSTANT TENSION WINCHES.** This research winch holds a constant tension in the cable thus eliminating tension and depth fluctuations caused by ship reaction to wave motion. By utilizing a new servo controlled hydrostatic drive, cable breakage and depth holding problems are minimized.



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DEPARTMENT OF MARINE TECHNOLOGY

**USI Technical Center**

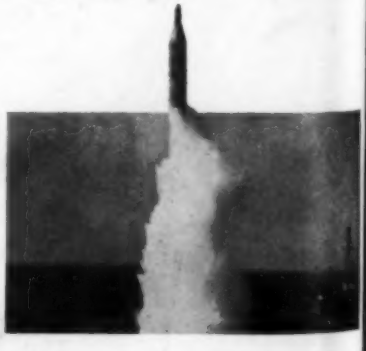
Pompano Beach, Florida

# PINOCCHIO *• so the story goes . . .*

gave a whale a bad case of heartburn and, thereby, effected his return to the surface. The puppet's idea, however, doesn't approach the ingenuity needed to solve the problems involved in accurately launching *underwater* the Navy's *POLARIS* missile. Like Pinocchio, the *POLARIS* must get topside before it can perform its vital mission, if need be . . .

WTA engineers are assisting Special Projects, Navy Bureau of Weapons in studies and design of essential test and support equipment for the *POLARIS Fleet Ballistic Missile System which is expected to become operational in late 1960.*

*research*
*development*
*design*
*prototypes*
*testing*
*production*



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